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FAST RAILWAY RUNS are being made by the Baltimore & Ohio R. R. express trains, between Philadelphia and Washington, 136 miles. The schedule time is 53 miles per hour, and the maximum obtained is 75 miles per hour, the latter speed being only maintained for short distances, and in most cases when enginemen are attempting to make up lost time. On Nov. 4, train 510, with engine 1310, hauling 4 cars, covered 96.7 miles in 124 minutes and made 4 stops. This train covered 61 miles in 65 minutes, including 5 minutes crossing the Susquehanna River bridge. On Nov. 6, train 511, engine 849, with 4 cars, covered 25.6 miles from Aberdeen to Bay View in 24 minutes. On Nov. 10, train 501, engine 1309, with 6 cars, covered 96.7 miles in 123 minutes, including 4 stops; 25.6 miles of this distance, Aberdeen to Bay View, was covered in 25 minutes. On Nov. 13, train 504, engine 1308, with 6 cars, covered 96.7 miles in 121 minutes, including one stop. Probably the best performance was on Nov. 15. Train 507 (the Chicago limited), with engine 1308, hauling 11 cars, the entire train, with the exception of 3 cars, being vestibuled, left Camden Station, Baltimore, at 7.04 p. m. and arrived in Washington at 7.52 p. m., being a run of 40 miles in 48 minutes. This train covered the distance between Muirkirk and Alexandria Junction, on the Washington Branch, 8.1 miles in 7 minutes. This was an exceptionally good run, when it is taken into consideration that the speed had to be slow through the cities of Baltimore and Washington, and there was one slow order on account of sewer construction.

A PARALLEL RAILWAY SCHEME at Catskill, N. Y., was recently nipped in the bud by the New York Railroad Commission. The proposed road was projected by the Catskill, Cairo & Windham Street Ry. Co., and ran parallel with the line of the Catskill Mountain Ry. Co. for its entire length. In its decision refusing the application the Commission said:

After a personal inspection of the proposed route and the existing line, and upon the evidence submitted, it seems to the Board that there is not business or traffic enough to authorize the construction of an additional railroad. The existing line is not self-sustaining and has not been at any time since its construction. It has ample facilities to transact all the business that is offered or which is likely to be offered for several years to come. From the applicant's own evidence it is apparent that the travel along the proposed route is not such as would make the construction of this road a public convenience and necessity as contemplated by the statute.

ELECTRIC TRACTION on the suburban and Coney Island lines of the Long Island R. R. is being considered by the company, in order to introduce a frequent service of cars instead of the less frequent service of trains now in use.

ELECTRIC TRACTION may be introduced on a part of the line of the Cincinnati, Hamilton & Dayton R. R. The company has acquired the street railways of Middletown, O., and will connect them with its own line, running cars through between Middletown and Hamilton by electricity. The system may also be extended to some of its suburban lines at Cincinnati.

A STEAM CARRIAGE OR OMNIBUS, built by Mr. M. Scotte, of Epernay, France, is now in service between Picauville and the nearest railway station. The motor car consists of a front compartment for the engine and a back compartment for 14 passengers. The trail car will seat 24 passengers. The 16-HP. engine is of the vertical compound type. The boiler is vertical, and carries a pressure of 50 lbs. per sq. in. The power is transmitted to the rear wheels, and the forward wheels are employed for steering, being pivoted around a vertical axis by means of a wheel directed by the engineman. The coal or coke for fuel is carried forward, and the bunkers will admit of about 450 lbs., or sufficient fuel to serve for four hours of travel; 150 gallons of water are carried in the tanks situated under the seats and under the floor. The dimensions of the motor car are 17 ft. in length and 6 ft. wide. Its weight is 7,700 lbs., without passengers. It will turn in a circle of 12 ft. diameter.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment on the Bald Eagle Branch of the Pennsylvania R. R., at Unionville, Pa., Nov. 18. A broken car axle was the cause of the accident, and 20 coal cars were smashed in the wreck. One trainman was killed and another injured.——A runaway westbound freight train on the Denver, Leadville & Gunnison R. R. jumped the track at a curve at the foot of a steep grade east of Webster, Mo., Nov. 14. One man was killed and three were injured, while the engine and 14 cars were smashed.

A LASSOED LOCOMOTIVE caused considerable damage at East Liverpool, O., Nov. 18. While hoisting the steel floor beams of the new bridge over the Ohio River, which spans the Cleveland & Pittsburg R. R., a wire cable was allowed to slacken so that it almost touched the rails. A heavy freight train was approaching, and the bridge workmen tried to raise the cable out of the way, but the smokestack of the locomotive struck it, carrying it nearly 600 ft. Telegraph poles, signal towers, and telegraph wires were snapped off and the traveling crane cars on the new bridge were upset. The rope was pulled out of the Ohio end of the bridge reel, and this prevented injury to property and loss of life of bridge employees, and persons in stores, residences, and on the streets. One end was thus finally freed before the train was stopped, and fell from the locomotive on the side of the track next to the bridge. The engine was considerably damaged, and part of the smokestack was torn away.

A LOCOMOTIVE BOILER EXPLOSION occurred Nov. 17 on the Atlantic Coast Line R. R., near Richmond, Va., and two men were badly scalded. The engine was hauling a freight train when the crown sheet collapsed.

A BROKEN STEAM PIPE on the tugboat "Hudson," while the boat was at Kinderhook, N. Y., Nov. 18, resulted in severe injuries to the engineman and fireman, and the latter died soon after the accident.

A HIGHWAY BRIDGE OR TRESTLE over Village Creek, near Ensley City, Ala., gave way under a wagon Nov. 22; one person was killed and 12 were hurt. It is said that the stringers were too short and had slipped off the end sills.

BIDS FOR A STEEL POCKET DUMP at the foot of East 17th St., East River, New York city, are wanted by the Commissioner of Street Cleaning until Dec. 3. About 150,000 lbs. of structural steel will be required, together with wrought and cast iron in small quantities, and some 30,000 ft. B. M. of timber and boards. Col. Geo. E. Waring, Jr., M. Inst. C. E., is Commissioner of Street Cleaning.

THE BROOKLYN DRY-DOCK ACCIDENT, of last August, has at last been passed upon by the Secretary of the Navy. The court of inquiry convened held Mr. A. G. Menocal, C. E., U. S. N., and Mr. U. S. G. White, C. E., U. S. N., responsible for the accident to the caisson, stating in effect that these officers should have transferred the ballast from the hold of the caisson to the upper deck, instead of entirely removing it, before replacing it with concrete; that notwithstanding their calculations, the entire removal of the ballast was unprecedented and they should have taken no risks, even to save some trouble and expense. The court recommended a court martial; but Secretary Herbert, while upholding the finding of the court of inquiry, "in view of the long service of these officers," will not order a court martial, but "reprobates their conduct," and charges the damage done to "a want of knowledge of which you ought to have possessed yourselves before acting."

THE PNEUMATIC MOTOR SYSTEM of the U. S. Monitor "Terror," was fully tested at sea, on Nov. 19, in steering the ship, turning the turrets and loading and pointing the 10-in. guns. The two air-compressors employed compress the air directly into an 8-in. pipe running through the ship, no other reservoir being used. In this pipe a pressure of 125 lbs. to the sq. in. can be developed in 45 seconds. From this main, small pipes lead to the steering gear, turrets, shell hoists, etc. In the trial the rudder was turned from hard a-port to hard a-starboard in 6 seconds. In 3 seconds a turret weighing over 250 tons was set moving, and in 52 seconds both turrets were turned completely around by compressed air. The first 10-in. gun was loaded in 1 min. 37 sec.; including the lifting of the 500-lb. shell and the powder from the magazines, and the loading of the gun and ramming home of the charge, all by pneumatic appliances. Some trouble occurred during the test from the lack of any previous drill, but the working of the pneumatic system was pronounced successful. At the same trial the four 10-in. guns were fired simultaneously by electricity, with full service charges and shells. This is a thing said to have been never before tried on an American war-ship, and the "Terror" stood the test well.

THE NEW BATTLE-SHIP "IOWA" had a trial trip, in charge of her builders, the Cramp & Sons Shipbuilding Co., on Nov. 13. The course was 10 knots in length, located 20 miles east of the Delaware capes. Four trips were made over the course, the average speed being 16.27 knots with 112 revolutions of the screw per minute. The speed guaranteed by the builders was 16 knots. The horse-power developed by the engines was approximately 11,000. The official trial is expected to be made in February.

EXTENSIVE INDUSTRIAL DEVELOPMENTS AT Niagara Falls and vicinity are expected soon to result from the successful transmission of electric power from the Falls to Buffalo and the increased power equipment of the two power companies, the Niagara Power Co., which owns the great tunnel, and the Niagara Falls Hydraulic Power & Manufacturing Co., whose plant on the side of the cliff below the falls was described in our issue of Mar. 26. The former company intends to place in position as soon as possible five more 5,000-HP. dynamos. The extension of the wheel pit to receive the turbines is now being made. Among the new developments in the vicinity is the plant of the Matthiesen Alkali Co., which is expected to be ready to operate Jan. 15, 1897. The Niagara Development Co. will build 25 new houses at Echota in the spring. The Pittsburg Reduction Co. has started its new aluminum plant, taking power from the new electric plant of the Niagara Falls Hydraulic Power & Manufacturing Co. The production of aluminum by electric power from Niagara Falls is now so great a success that the Pittsburg Reduction Co. has found it advantageous to abandon its plant at Patricroft, England, and make all its product in this country.

ALUMINUM IS USED TO CONDUCT ELECTRICITY in the new aluminum works of the Pittsburg Reduction Co. at Niagara Falls, transmitting current from the generators in the power house to the electric furnaces in the melting house. The electric conductivity of aluminum, according to M. Lazare Weiler's table, is 54.2, pure copper being 100. The specific gravity of aluminum is 2.67, and that of copper 8.85, or 3.32 times as much. To carry the same current as could be carried by a rod of copper of 1 sq. in. section would require $1 \div 0.542 = 1.845$ sq. in. of aluminum, and this would weigh only $1.845 \div 3.32 = 0.556$ of the weight of the copper. If the cost per pound of aluminum were only 1.8 times as much as the cost per pound of copper, then the cost of a conductor of each of the metals would be the same.

THE NAIL TRUST has collapsed. It began in June, 1895, and it in one year had advanced the price of wire nails from 95 cts. to $2.70 per keg. In one year it made 6,000,000 kegs of nails. It taxed the dealers 15 cts. a keg, which tax was refunded to them at the end of six months on proof that they had not cut the selling prices. It paid competing manufacturers to close their works, or bought them outright. It got control of the nail machine makers so that no one outside of the trust could buy a nail machine, and ran things with a high hand generally. The yearly average prices of nails at Chicago for the five years previous to the formation of the trust were: 1890, $2.51; 1891, $2.04; 1892, $1.70; 1893, $1.49; 1894, $1.11. In April, 1895, the average price was 95 cts., and on May 1, 1896, the price was fixed by the trust at $2.70, after repeated advances during the year, and this price has since been maintained. The collapse came about through the starting of several small nail factories which bought a new nail machine recently put on the market and which the trust failed to capture. Nails at Chicago have already dropped to $1.70 per keg, and the price is expected to go to $1.25.

AMERICAN CITIZENS ONLY can be employed by the contractors for the improvement of the New York State canals. This is in accordance with the law passed May 10, 1894 (Chapter 622, Laws of 1894), relating to the employment of mechanics and laborers upon public works. This law forbids the hiring of any but American citizens for labor performed for the state of New York or for any municipal corporation in that state, and the same law requires the contractors for such work to pay the men not less than the prevailing rate of wages for similar services.

NICARAGUA CANAL LEGISLATION, says Mr. J. R. Bartlett, of the Nicaragua Canal Company, is not to be "forced" upon Congress at its next session. "A moderate attempt" will be made to secure favorable action; but meanwhile private negotiations for foreign capital will be resumed where they were broken off by the Venezuela proclamation of President Cleveland. Mr. Bartlett says that at that time English capitalists had agreed to advance $00,000,000 towards the construction of the canal.

NOTES OF A TRANSCONTINENTAL TRIP.

V.

San Francisco.

This is a large and attractive city, having a population of about 400,000. It is situated on the north point of a peninsula, 30 miles long, which separates San Francisco Bay from the Pacific Ocean, the northern side of the city fronting on the Golden Gate, and its eastern side on the bay. The far-famed Golden Gate is the narrow strait connecting the bay with the ocean, so that the great bay, with an area of about 600 sq. miles, is almost entirely land-locked. This strait forms the only break for some hundreds of miles in the low coast range of hills which rise directly from the shore. A peculiar meteorological result of this break in the range is that San Francisco is practically never hot, for in the afternoon of a warm day the wind from the sea will begin to pour through the strait as through a funnel, until by the evening there will be a chilly gale blowing. The climate is remarkably mild and equable, being free from extremes of heat and cold. I had expected to find this an exceedingly hot place after the great heat on the Sierras, but while other towns in the state were experiencing temperatures of 80 to 96°, the temperature in San Francisco rarely got as high as 75°, and then only for a short time, while every night was cool and fresh. There is a great deal of fog on the coast, and looking up Market St., during a sunny day, there is often to be seen a grey darkness over the hills between the city and the coast, which to a stranger appears to presage a heavy thunderstorm, but the clouds do not approach and the sunshine remains unobscured. Taking a car for the shore, which is about 7 miles distant, one finds the air growing colder and damper, while along the crest of the coast range can be seen a mass of white vapor rolling down on the east or landward slopes, but not getting very far. This is found to be a wet sea fog, which settles close down on the water, and it is this fog, coupled with the many dangerous points of the coast, which has led to the loss of so many steamers in this vicinity. On returning to the city, the fog is gradually left behind and the sunshine is again reached.

The city government is far from being satisfactory, as it is run mainly on a political basis and with personal and party ends in view. There is a city surveyor, but no city engineer, and the street commission has no engineer. The sewerage system is very imperfect and many of the sewers are in a dilapidated condition, caving in quite frequently. In 1892, a sewer commission was appointed to investigate the condition of the system and to report upon the means of improving it. For political reasons, however, it was legislated out of office in 1893, before it had done anything beyond making a preliminary report which conclusively showed the faulty condition of the work as existing. This commission was composed of Mr. Irving M. Scott, Col. G. H. Mendell, U.S. Engrs., Mr. Geo. Davidson, Mr. Marsden Manson, and Mr. C. E. Grunski. The street paving is not very good as a whole, but the sidewalks are in much better condition. Concrete or artificial stone is largely used for the sidewalks, and it is specially noticeable that it has a rougher and coarser surface and is consequently much less slippery, than the cement paving commonly used in the East.

An engineer notices the great extent to which concrete is used for garden walls, retaining walls, sidewalks, steps, gate posts, sidewalks, etc., and even for the basement walls of buildings, the exposed surface in these latter cases being finished to imitate rock-faced stone. The reason for this extensive use of concrete is the cheapness of Portland cement, which is brought here by ships as ballast, and costs very little, while the equable climate is very favorable to the durability of the concrete. A number of contracting firms devote themselves to this class of work as a specialty.

The topography of the city is irregular, there being several isolated hills, besides the range on the coast; the Mission Peaks are 925 ft. high, Reservoir Hill (in Golden Gate Park), 920 ft., while Russian Hill and Telegraph Hill are also points of interest. This makes the streets (which are laid out on a rectangular plan) very steep in places, so steep in fact that several blocks on the south slope of the ridge parallel with the Golden Gate are impassable for teams, and can only be used with much exertion by pedestrians. It was on locations like these that the cable railways were first established, and it is here that the cable railways are found to be of special interest. San Francisco is in fact the home of the cable railway, which was first introduced there by Mr. Andrew S. Hallidie, in 1873. The first line was the Clay Street Hill Ry., with 5,197 ft. of double-track and a maximum grade of 16.26%. A ride on any one of the lines built along the ridges where grades of 18 to 23% occur, such as the Powell St., California St. or Sutter St. lines, is really more thrilling to a stranger than is the ascent of Pike's Peak. In the latter case the train ascends slowly and this gives the impression of great care and caution being taken, while the cable cars climb rapidly up a series of short steep grades (broken by the level stretches at street intersections) and then as rapidly run down similar grades from the summit level. Curves are also traversed quite rapidly and on some of the lines the up and down motion almost conduces to seasickness. Various styles of grips are used, some having the jaws moving vertically and some horizontally, and both wheels and levers are used to operate the grips. On some lines short open grip cars are used, hauling short four-wheel, closed trail cars, but the more important lines have very long cars on two four-wheel trucks, half of the car being open (with seats back to back and the grip levers between) and half closed. The car bodies are set low on the trucks, so that it is an easy step to the platform. Ordinary wheel brakes are used, but there is also a track brake fitted to one of the trucks, this brake having a wooden bar or shoe which is forced vertically down upon the rail. At many of the terminals turntables are used, smaller tables having one track engaging with one or other of the converging double tracks, while larger turntables have two tracks in line with the main tracks. The turntables are of iron construction with a wooden platform at the street level, and some of them are operated by power derived from the cable. There is a most extensive system of transfers between the various connecting and intersecting lines, while since the opening of the Sutro electric line to the Cliff House, the trip of about 7 miles from the city to the shore can be made for 5 cts. Electric traction is employed on many of the more level lines, the cars being large combination cars, as on the cable lines, and it was noticeable that here (as in other western cities) the conductors did not have as much to do in looking after and replacing the trolleys as they do in many eastern cities. There are two steam lines to the shore, operated by double-end saddle tank engines; one of these has open-sided excursion cars, while the other (following the shore of the Golden Gate and opening up some wonderful scenery) has a curious style of car with an open section at the middle and a closed section at each end.

There are many fine offices and store buildings, but the craze for "sky-scrapers" has not yet broken out to any extent, though the proprietors of the San Francisco "Call" are now erecting a 15-story building of steel skeleton construction. The new Parrott Building is a large steel building with many interesting features, including a great dome over the center of the first floor (in the central light court).

One of the notable buildings of San Francisco is

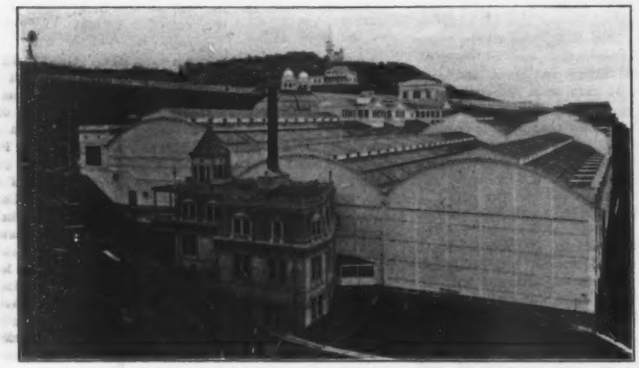


FIG. 1.—VIEW OF THE SUTRO BATHS AND SUTRO HOUSE.

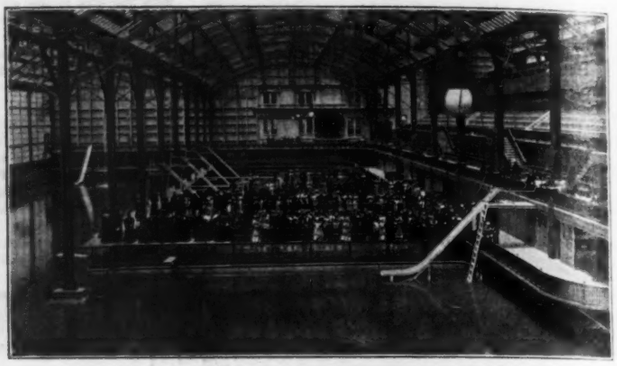


FIG. 2.—INTERIOR VIEW OF THE SUTRO BATHS; SAN FRANCISCO.

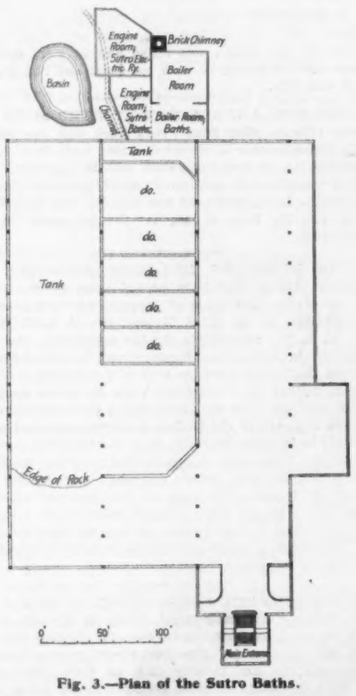


Fig. 3.—Plan of the Sutro Baths.

the Palace Hotel, which was of almost unprecedented size and magnificence when built some years ago, and is still a very striking building. It occupies an entire block, 275 × 350 ft., and is in the form of a hollow square, with light courts allowing for four rows of rooms on each side. It has seven floors above the ground floor and can accommodate 1,200 guests. The central court is carried up to the roof, which is of glass, and around it, on each floor, is a broad corridor or gallery. Carriages drive into this court and leave guests right at the

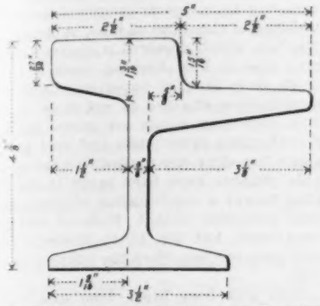


Fig. 4.—70-lb Rail for Street Railways; San Francisco, Cal.

door of the hotel office. The whole effect is enhanced by the handsome finish of the fronts of the galleries, with white balustrades and pillars, and the liberal use of palms and tropical plants. All the water for the use of the hotel is filtered in a large filter plant erected on the roof of the building.

The street cleaning of the city is done under the management of the Merchants' Association, and the men are dressed in a uniform consisting of a brown canvas jacket or jumper, overalls of coarse brown duck, and a blue cap with the name of the association in gilt letters. At the foot of Market St. is a large railway office and waiting room for the ferries to the railway station at Oakland and to the various towns situated across the bay. Work is now in progress upon a large new steel structure, which is being built under the supervision of Mr. Horace E. Brown, Engineer to the Harbor Commission. The Risdon Iron Works, of San Francisco, have the contract for this work. At Oakland some land reclamation work is going on to form a site for coal bunkers. Mr. Grunsky is the engineer, and Mr. Otto von Geldern is in charge of the work for him.

The sea coast is reached by either one of two steam railways, or the Sutro electric railway, all starting from the suburbs of the city and converging near the celebrated Cliff House in front of the Seal Rocks. The old Cliff House was burned on Dec. 24, 1895, but a larger structure was at once built, and is a great resort for tourists and people from the city. North of the Cliff House are the new and extensive Sutro baths. On top of the hill (shown in the eastern view of the Sutro baths, Fig. 1) and overlooking the ocean is Sutro Heights, the residence of Mr. Adolph Sutro, Mayor of San Francisco, but who is most widely known from his connection with the famous Sutro tunnel on the Comstock lode in Nevada. The grounds of his establishment are open to the public.

The Sutro Baths.

On the shore, and close to the Cliff House, are the new Sutro baths, established and built by Mr. Sutro, and which were opened in March, 1896. The buildings are handsome and spacious, and form a pleasure resort for visitors as well as bathers, there being a museum and other attractions, and cheerful promenades lined with palms and growing plants. The entire building is 499.5 × 254.1 ft., and contains about 600 tons of ironwork in the columns and roof trusses, 270,000 cu. ft. of concrete, 3,500,000 ft. of lumber and 100,000 sq. ft. of glass. Provision is made for spectators at aquatic sports and swimming matches, there being seating capacity for 3,500 persons in the amphitheatre, and 3,500 on the promenade, while the total capacity of the building, including the aisles, etc., is 25,000 persons. There are seven swimming tanks, as follows: One large tank, 1,409,062 gallons capacity; 4 small tanks, 70, 283, 400 and 875 gallons; 1 medium size tank, 112,500 gallons; 1 fresh water tank for plunges. There are 9 spring boards, and 7 toboggan slides lined with sheet brass and having a continuous stream of water running down them. These are shown in the general interior view, Fig. 2. There are 517 private dressing rooms and 9 club rooms, the total capacity being 1,110; 29 dressing rooms and all the club rooms are fitted with shower baths, and there are 66 shower baths in all. The laundry equipment can handle 20,000 bathing suits and 40,000 towels per day. The restaurant is on these floors, with an area of 30 × 75 ft. on each floor.

The water for the baths is taken from the waves or rollers which break on the reef on which the baths are built. A catchwater basin 75 × 150 ft. was blasted out of the rock, and this receives the water from the waves, which then flows to the receiving pond, and through a tunnel to the settling tanks, whence it goes to the various bathing tanks. With a high sea rolling in, the tanks can all be filled in an hour. A centrifugal pump with a capacity of 6,000 gallons per minute keeps up a constant circulation, and can fill the baths in from 5 to 6 hours. The tanks can all be emptied in an hour, at high or low water, through an outlet of 24 inches diameter, the waste water being led away to a point where it is discharged into a tidal current, so that there is no chance of its being at once taken in again. The water is heated by a system devised by Mr. Sutro, using direct steam driven through small tunnels. The temperature is graduated in the different tanks, and in the smaller tanks it can be raised 10 or 20° in a few minutes. The bath buildings are protected on the west by a breakwater lying north and south, 400 ft. long, 20 ft. deep, 25 ft. wide at the top and 75 ft. at the base, containing 450,000 cu. ft. of rock; another breakwater runs east and west, this latter being 300 ft. long and of the same cross section, containing 300,000 cu. ft. of rock. A general plan of the establishment is shown in Fig. 3.

The power house contains three compound vertical, direct connected engines of the marine type. Two of these operate the Sutro Electric Ry.; the larger has cylinders 16 × 24 ins. and 32 × 24 ins., and is rated at 600-HP. at 150 revolutions per minute; the other has cylinders 11 × 18 ins. and 22½ × 18 ins., and is rated at 300 HP. at 200 revolutions per minute. Each engine has its own surface condenser, through which the water from the ocean flows on its way to the baths. The engines drive dynamos of 400 K-W. and 200 K-W., respectively, the smaller being sufficient during week days, when only about 8 cars are running, and the larger being used when the traffic is heavy, while both engines are run together on Sundays, the traffic then being exceptionally heavy.

The third engine drives two 75-K-W. generators for the electric lighting of the baths. All the engines have steam jackets on the cylinder walls and heads. Each cylinder has two separate steam valves and two separate exhaust valves, the former (on both cylinders) being controlled by the engine governor. The engines were built by the Fulton Iron Works, of San Francisco, and the dynamos by the General Electric Co., of Schenectady, N. Y. Steam is supplied by three Babcock & Wilcox water-tube boilers, carrying 140 lbs. pressure, and the fuel is Welsh anthracite coal, costing $7 per ton. Records of coal consumption, currents, etc., are taken daily, and account is taken of the amount of the total power consumed by the railway, the pumps, and the Frith wheel and other attractions. The baths were designed and built under the personal direction of Mr. Sutro, and they, as well as the electric railway, are among the many works built by Mr. Sutro for the benefit of the people of San Francisco.

Business and Industries of San Francisco.

Union Iron Works.—These works have a very extensive plant for machinery and shipbuilding. The company is naturally proud of its work on the warships "Oregon" and "San Francisco" for the U. S. Navy, while since my visit it has obtained the contract for one of the new battleships, and very recently for a battleship for Japan. Besides the ordinary machine shops, foundry, etc., it has a galvanizing plant, extensive ship-yards, a large floating dry-dock and a storage space piled up with spare propellers, shafts, engine fittings, etc., for the various steamers built. A large new boiler shop is being built, and a new three-story office building, the lower story of this latter being of rock-faced monolithic concrete, while the upper part is of pressed brick with stone trimmings. The concrete work is being done by Keatings & Leonard, licensees for the well-known Ransome system of concrete and twisted iron construction, who have done a considerable amount of work of this kind. All kinds of iron and machine work are done here, and at present a good deal of mining machinery is being turned out, the works being quite busy and employing some 2,000 men. In the shops are some exceptionally large machine tools which were designed and built at the works. The great compound hoisting engines built for the Anaconda copper

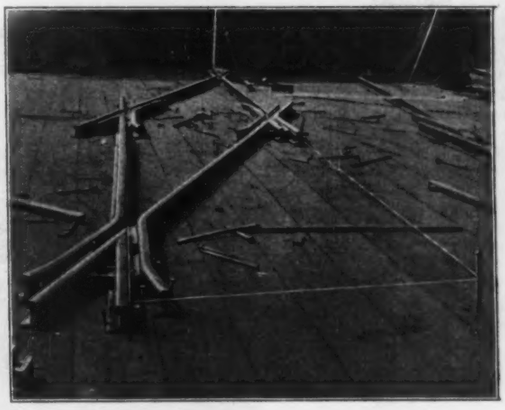


Fig. 6.—Track Crossing; Built by the Pacific Rolling Mills.

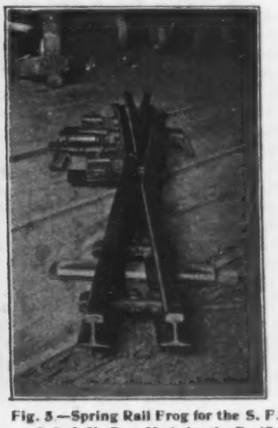


Fig. 5.—Spring Rail Frog for the S. F. & S. J. V. Ry.; Made by the Pacific Rolling Mills, San Francisco.

mines were illustrated and described in Engineering News, Sept. 3, and at the time of my visit the following work was in progress: Two sets of double-acting hoisting engines, with two cylinders, 30 × 72 ins., on each side; one similar engine, with cylinders 20 × 60 ins.; a 20-stamp silver mill for Mexico; three sets of 1,200 HP. triple-expansion engines of marine type, with direct-connected dynamos, for the Market St. Ry.; nine elephant boilers, 160 lbs. pressure, fitted with Rooney stokers, for the Market Street Ry.; triple expansion engine of 2,800 HP. for the Pacific Coast Steamship Co.; two gunboats; a steamer of 600 tons for the Sandwich Islands. The repairing and overhauling of steamers is an important feature of the firm's business.

Pacific Rolling Mills.—The works were first started for the manufacture of bar iron, and then, when the Central Pacific Railway was being built, they made great quantities of ironwork for cars, since which time the plant has grown very

extensively. The principal orders now on hand are for structural work, but include also some small highway bridges (80, 120 and 140-ft. span), and there is a considerable amount of minor work in hand, such as spikes, bolts, nuts, and the rod bands for wooden stave pipe. The ironwork for the Parrott building, with its great dome, and the dome on the City Hall, were turned out from these works. Z-bars are among the sections rolled; in fact, it is claimed that this was the first mill to roll such a section in this

Fig. 7.—Cast Steel Piston; Made by Pacific Rolling Mills.

country, it having been made originally for one of the warships, the plans for which were purchased abroad, and it was desired to substitute one section for a double-angle section shown on the plans. Short pieces of Z-bars, used in pairs, are used on some of the street railways as chairs for the side-bearing girder rails. The works have 8, 10, 12 and 15-in. mills, and also roll light T-rails, up to 40 lbs. per yd., and street rails up to the 70-lb. side-bearing section now generally used for the city's street railways, and this is shown in Fig. 4. A somewhat new line of business for the Pacific Coast which has recently been taken up by these works is the manufacture of switches, frogs and crossings for railway and street railway work, and a considerable amount of work of this kind has been done for the new San Francisco & San Joaquin Valley Ry. Fig. 5 shows a spring rail frog for this railway, and Fig. 6 shows a crossing under construction. Some large steel-framed turntables for street cars have also been built, including one in front of the Chronicle Building, which is operated by gearing, the cogs of the turntable rack being formed by bolts through two concentric rings. There is a steel plant for the manufacture of steel castings, large and small, the work including pistons for locomotives, 7 ft. pistons for some of the new cruisers, Fig. 7, and the large stern frame castings for these vessels. The rolling mills are driven by a large engine of the Corliss type with a form of valve gear specially designed to cause the engine to follow up the load on the mill quickly and then release it quickly. Oil fuel is used for the boilers, being brought up from southern California in tank steamers and pumped from the vessels to the storage tanks. Gas heating furnaces are used, having valves underneath for the purpose of economizing space, and there is a very interesting hydraulic charging machine, revolving on a turntable. The furnaces, charging machine, and many other interesting parts of the plant were designed by Mr. Patrick Noble, general manager, who has been associated with the works for 28 years, and who may be seen in Fig. 7, standing at the side of the casting.

Pelton Water Wheel Co.—This firm is one of the few whose business does not seem to have suffered from the prevailing depression, this fact being due mainly to the present great activity in water power projects. The lowest head under which any Pelton wheel is now working is 14 ft., while the maximum is 2,100 ft., this latter being at Fresno, Cal., as described in Engineering News, July 2. Cast-iron buckets are used for the ordinary heads and phosphor bronze buckets for wheels working under high heads.

Alcatraz Asphalt Co.—This company has recently carried out some successful work of asphalt paving on a gravel foundation or base, and has lined several reservoirs for the Oakland Water Co., of Oakland, Cal. (the new rival of the old Contra Costa Water Co.), using a 4-in. layer of asphalt painted with an asphalt paint.

A. Lietz Co.—This company, manufacturing engineering instruments, makes a specialty of the cyclotomic transit, recently described in Engineering News. This instrument costs less than an ordinary transit, but is claimed to be more accurate and more durable. It is true that angles cannot be repeated with it, but it does not seem that many engineers do this, or consider it necessary, as already a large number of the new instruments have been sold. Mr. Lietz has a special aluminum alloy, containing 70% aluminum, which he uses for standards and other parts of instruments and which is sufficiently hard to require no bushing for screws and bearings. The standards are designed to give great stiffness, and the instruments are found to be very rigid, even in high winds. The aluminum is also used for the telescope tubes. An 18-in. Y level, with aluminum fittings and weighing only 6 lbs. has been successfully used in windy weather by the engineer of the Harbor Commission.

Excelsior Wooden Pipe Co.—The use of wooden stave pipe is becoming very general in the western states, to convey water over long distances for irrigation or domestic supply, and this pipe has been frequently described and illustrated in Engineering News. In the larger sizes of pipe the staves are built up to shape on a collapsible form or centering, and in pipes of less than 18 ins. diameter a "rounding-out" machine or mandrel is used to bring up sunken staves to the proper contour, as the other staves cannot be driven down. This was designed for use on the water-works system of Hollister, Cal., which were the first works on which wooden stave pipe of 10 and 12 ins. diameter was used. In adobe soil, which is corrosive to steel, the wooden pipe has many advantages. The sides of the staves are carefully trimmed by planing knives to the radius and curve of any given diameter of pipe, and then a test section is set up to test the accuracy of the fit of the staves, as any slight error, multiplied by the number of staves forming the circumference of the pipe will make a badly-shaped pipe. At each end of each stave is a saw cut, and in one of these is inserted a steel strip of such length as to leave a 1-12 in. open joint between the staves, the staves being then driven up with a 16-lb. sledge, thus forcing the steel slightly into the wood and making a tight joint. The steel strip is also slightly wider than the stave, so as to cut into the sides of the adjacent staves. It is evident that special care and attention are required for the successful building of this kind of pipe. A firm of sewer contractors which received a contract for a wooden pipe line at Los Angeles, made a failure of the work from lack of experience, and caused very considerable expense to get it in working order. The encircling bands are round steel rods, with Sternbergh's upset ends and cold rolled threads, while the clips are malleable castings. Considerable changes have been made in the form of the clips to get a continuation of maximum strength with minimum weight. Rods of oval section have been tried, but Mr. D. C. Henney, the manager and engineer, considers the circular section preferable.

Steel and Iron Pipe.—Iron and steel pipe are supplied by three principal firms. Dunham, Kerrigan & Hayden, hardware merchants, make this one of their specialties, and have an engineer, Mr. Thomas Brooks, in charge of this department. He reports a number of cases where this pipe has been used under very high heads. The collapse of riveted steel pipe by external atmospheric pressure, when the water in the pipe has been suddenly drawn off by an accident (causing a vacuum in the pipe) led Mr. Brooks to devise a special form of air valve to give ample area of opening from the exterior in case of such an emergency. This firm supplied the pipe line for the power plant at Fresno, Cal., the total length of which was 4,020 ft., with a head of 1,400 ft., including 20-in. lap-welded pipe and 24-in. riveted steel pipe. Two forms of joints were used, the Converse lock joint, and a bolted flange joint, the cast-iron flanges being shrunk on and headed to the pipe and reinforced by ¾-in. rivets. One flange of each joint has a recessed face and the other a projecting face, a 3-16-in. rubber gasket being placed between the flanges, which are then drawn up by 16 bolts 1 in. diameter, 10¼ ins. long. The 31,500 ft. of steel pipe for the Hollister water-works, above noted, was supplied by W. W. Montague & Co., of San Francisco.

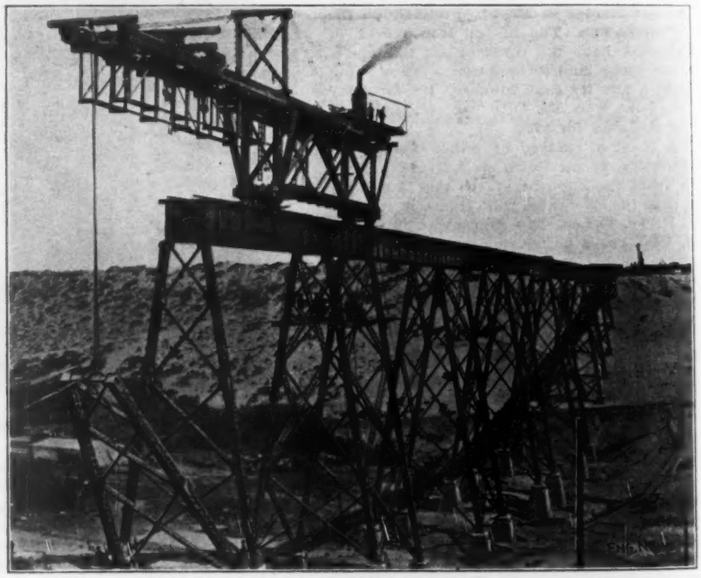


FIG. 8.—LOS ALAMOS VIADUCT; COAST LINE DIVISION, SOUTHERN PACIFIC RY.
Erected by the Thompson Bridge Co.; San Francisco, Cal.

Bridge Companies.—Bridge work is at a very low

ebb and the companies making this work a specialty are practically idle. The San Francisco Bridge Co. has built some wooden bridges with pile abutments for the new San Francisco & San Joaquin Valley Ry. The Thomson Bridge Co. has erected some of the bridges and trestles on the new Coast Division of the Southern Pacific Ry., including the Santa Maria River Bridge with seven spans of 183 ft., and the Los Alamos viaduct, 734 ft. long, with plate girder spans on metal bents. A view showing the erection of this viaduct is given in Fig. 8. The bents are raised by the derrick on the traveler, and the plate girders were run out onto the structure on flat cars, and then run out through the traveler trusses by means of trolleys and slings, and set in place on the bents. Mr. Thomson says that the piles along the harbor front at San Francisco are supported entirely by skin friction, not reaching any firm bottom; these piles are ordinarily 80 to 90 ft. long, but he has driven Oregon pine piles 135 ft. long, 16 ins. diameter at one end and 6 to 8 ins. at the other.

Railways.

The most important railway work now in progress in California is that of the San Francisco & San Joaquin Valley Ry., which starts from Stockton (whence steamers run to San Francisco) and runs down a rich fruit and wheat-growing country, its objective points being Fresno and Bakersfield. The railway parallels two lines of the Southern Pacific Ry. but will develop a large local traffic. All switches and frogs, and many of the cars have been built by firms on the coast, mainly to designs prepared by the engineer, as this was a new character of manufacture in that district. Particulars of this road and its structures were published in our issue of Oct. 29. The Southern Pacific Ry. is building a new coast line to Los Angeles, having maximum grades of 1% as against 2½% by the present line over the Tehachapi Pass, on which summit grades two twelve-wheel engines are used for freight trains and two ten-wheel engines for passenger trains. One of the viaducts on this line is shown in Fig. 8. The new line is laid with 75-lb. rails and has an excellent track, being intended for fast traffic. This road is also building some small branches near Pomona, for which Grant Bros., of San Francisco and Los Angeles, are the contractors.

THE NEW POWER PLANT OF THE WASHINGTON MILLS CO., LAWRENCE, MASS.

(With inset.)

The Washington Mills, of Lawrence, Mass., since their reorganization some ten years ago, have been enlarged by extending the area covered by buildings, adding stories to existing buildings, and by replacing old buildings by new ones until they are now claimed to be the largest woolen mills in the world. Originally, like all the Lawrence mills, water power was the sole reliance, but for some years a pair of 30-in. × 60-in. horizontal non-condensing engines have also been in use. They were designed by Mr. E. D. Leavitt, and were built by the Dickson Mfg. Co., of Scranton, Pa. They are worked from 2,000 to 2,400 I-HP. constantly. The exhaust steam from these engines is used in the dye-house.

Recently Messrs. Dean & Main, mechanical and mill engineers, 53 State St., Boston, Mass., have put in for the mills 1,100-HP. of Hercules water-wheels, making the total water power of the mill at ordinary stages of the river 3,500 HP., and they have designed a rope drive for transmitting the power from these wheels, and two steam boilers and an engine containing some other unusual features, the whole forming a unique power plant well worthy of description.

The extension of the mill have been so considerable that the total of steam and water power above noted, amounting to early 6,000 HP., has been insufficient during times of even small amounts of back water in the river, and especially during lighting up time, when 750 HP. is required to drive the electric lighting dynamos. This will soon be increased to 1,000 HP.

The Rope Drive.

The 1,100 HP. water wheels above referred to had to be so placed as to utilize an old waterway from the canal to the river; but this position was at some distance from the mill where the power was needed. It was necessary to transfer the power by a shaft westward some 80 ft., then southerly 103 ft., and vertically about 25 ft. After some scheming, it was decided to use for this purpose the "American" or continuous rope drive.

This drive is interesting, if not unique, because of its length and the great power transmitted. The rope wheels have 24 grooves for 1¾-in. rope, and 7,000 ft. of rope are used. The speed of the rope is 5,026 ft. per minute, and Kenyon cotton rope is used.

As shown in the drawing, the main rope wheel on the water-wheel shaft is 10 ft. in diameter. From it the rope passes upward, and thence over two 72-in. sheaves horizontally to the receiving wheel 76 ins. in diameter. The horizontal ropes are supported by two 72-in. carrying sheaves, and there is one 72-in. sheave used to direct one strand of the rope to the inclined take-up sheave which travels on a carriage. The movement of the take-up is very slight and maintains the tension of the rope satisfactorily.

To make this rope drive a success, it was thought to be only necessary to support it on a very rigid structure from one end to the other, in order to maintain alinement and prevent vibration. A heavy timber truss was built from one end to the other, with chords and posts of Southern pine, and diagonal straining rods in vertical and horizontal planes, provided with right and left hand nuts, the whole being firmly anchored to foundations.

The drive is successful, and it is impossible to say from its behavior, when running, whether it is carrying a load or not.

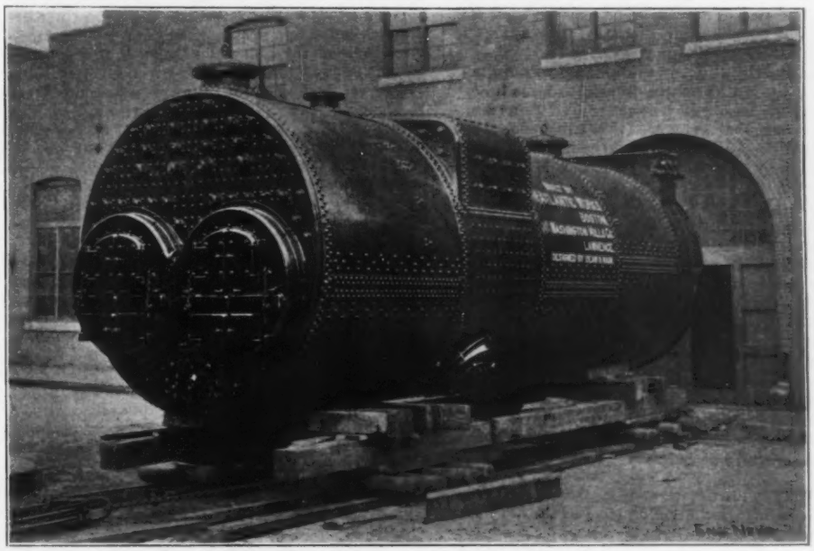
The Boilers.

About the time the rope drive was undertaken, it became necessary to provide additional boilers. The existing boiler house was full, containing eleven horizontal return tubular boilers, 78 ins. in diameter, with 2,190 sq. ft. of heating surface (fire sides of tubes) each, or 24,000 sq. ft. in all, and carrying 135 lbs. of steam. Although the grates were large, being 8 ft. by 7 ft., 25 lbs. of coal were being burnt per sq. ft. per hour.

There was no place about the mill where a new boiler house could be built. There was, however, a space of little value on the other side of the end wall of the boiler house, and otherwise forming its continuation, except that the overhead floor was much lower than that in the boiler house, which had been made high to accommodate horizontal return tubular boilers. To raise this floor was a very expensive job, and besides this it would ruin the room above for manufacturing purposes.

It was seen, however, that a special design of boiler could be made that could amply be accommodated in the space at hand. The design shown on the inset sheet was prepared by Dean & Main, and two boilers were built by the Atlantic Works, East Boston, Mass. Each boiler has two 48-in. Morrison corrugated furnaces, entering a combustion chamber, from which 590 2½-in. tubes pass to the smoke box. The grates are 7 ft. 6 ins. long, the bridge wall 12 ins. long, the combustion chamber 5 ft. long and 6 ft. 8 ins. high, and the tubes are 14 ft. long between the heads. The length of the boiler over all is about 31 ft. The heating surface of each boiler is 5,300 sq. ft., the grate surface 62.20 sq. ft., and the ratio of heating to grate surface 85.2 to 1.

The unusually large ratio of 85 to 1 was adopted because it is probable that these boilers will be rushed, as the old boilers have been, and it is desirable to have enough surface to take up the heat evolved. The relation considered in designing the boiler has been that between coal burnt and heating surface, rather than the usual one between grate surface and heating surface.



INTERNALLY FIRED BOILER FOR THE WASHINGTON MILLS, LAWRENCE, MASS.
Designed by Dean & Main, Engineers, Boston, Mass. Built by The Atlantic Works, East Boston, Mass.

The minimum inside diameter of the boilers is 9 ft. 10⅛ ins., and the maximum outside diameter 10 ft. 2 ins. The weight empty of each boiler is 90,000 lbs., and the weight of water held by it is 60,000 lbs., so that the working weight of each boiler is 75 tons in addition to the weight of the steam pipes, etc., resting upon it. Each boiler rests upon two cast-iron cradles, one of which is stationary, and the other rests on rollers of cold rolled shafting to permit free expansion and contraction.

Each boiler has two 6-in. pop safety valves which are set to blow at 135 lbs. gage pressure.

Each plate of the boiler was tested by the Pittsburg Testing Laboratory. All rivet, stay-bolt, and tube holes were drilled in place, and the rivets were driven by a hydraulic machine.

It is intended to have one fireman to each boiler and to burn one ton of coal an hour under each.

We would call attention especially to the means provided at the rear of the boilers for equalizing the flow of the gases of combustion through the upper and lower rows of tubes. In all horizontal fire tube-boilers there is a tendency for the gases to pass through the upper tubes rather than the lower, and in consequence a waste of heat results, the gases escaping from the upper tubes at too high a temperature. To counteract this tendency in these boilers three dampers have been placed in the stack, each controlling one of three portions into which the smoke chamber in the rear of the boiler is divided. These portions are made by hanging curtains or partitions in front of the tubes, so designed that they offer greater resist-

ance to the flow of the gases through the upper rows of tubes than through the lower, which resistance may be varied at will by operation of the dampers. To secure the best effect the velocity of the gases should be the same through all the tubes and the temperature of the gas discharged by each tube should be uniform. The latter may be determined approximately by very simple means, such as placing an iron bar in a tube for a sufficient time, suddenly cooling it by plunging in a weighed quantity of water, and determining the rise in temperature of the water by a thermometer.

A number of bars may thus be used at a time, to take the relative temperatures of several tubes in a vertical row, and the three dampers adjusted until the greatest uniformity in temperatures is obtained.

The Engine.

In view of the great amount of power required to drive the lighting dynamos, and of the importance of being as independent of low and back water as possible, it was decided to put in a new engine designed to develop some 1,000 or 1,200 HP. at its point of maximum economy, but capable of working at much greater power.

The proper location of the engine was quite a problem, but it was finally decided to have it connected to the new water wheel shaft. Accordingly this shaft was extended westerly beyond the rope drive described above into No. 3 Mill basement, and arranged to drive No. 1 Mill, which adjoins No. 3.

On account of scarcity of room, it was finally decided to take the rather bold step of placing this engine in the line of the above-mentioned shaft which runs at 100 revolutions per minute. It was decided also to have a vertical engine in order to save room, do away with cylinder cutting and reduce friction, to say nothing of saving cylinder oil. There are a sufficient number of precedents for fast running large power engines at present to make this a safe project if the engine is properly designed.

Specifications were drawn up by Dean & Main for an engine having the following leading characteristics: Vertical inverted, four-valve, cross compound, surface condensing, thoroughly steam jacketed and provided with a large reheater. Diameter cylinders, 25 and 50 ins.; stroke, 36 ins.; revolutions per minute, 160; piston speed per minute, 960 ft. Shaft to be of hollow oil tempered steel, and all of the main forgings to be of the same quality of steel, made very light.

The engine was made condensing because the old engines furnish about all the exhaust steam that can be utilized, and it was made surface-condensing in order to keep the condensing water clean for the purpose of using it in the dye-house, instead of the cold river water, as at present, which is heated by exhaust steam. Thus all of the heat rejected by the engine is used in the dye-house quite as effectively as if it had entered the water at that point instead of at the engine, with the advantage that much less steam is required for the power than would be required by a non-condensing engine. There is, moreover, less condensation in the engine, and less loss of heat between the engine and dye-house, than with the non-condensing engine. All heat that enters the engine goes to the dye-house, except the equivalent of the work done, that lost in the engine by radiation, jacket and reheater condensation, and of course that contained in the air-pump discharge. By removing the oil from it, the heat in the latter can be saved. The cost of coal for running this engine is, therefore, next to nothing.

The circulating pump not only sends the water through the condenser, but continues its course to the dye-house. The surface condenser has a combined circulating and air pump, the whole was made by the firm of H. R. Worthington. There is also an automatic receiver pump for returning the separator, jackets and re-heater condensations to the boilers, and the exhaust of these auxiliary pumps goes into the exhaust system of the old engines.

The contract for the engine was awarded to the Rice & Sargent Engine Co., of Providence, R. I. It will have Corliss valves, but the specifications required the low pressure valves to be worked by positive connections with the eccentrics, and to have a fixed cut-off at ¼ stroke, capable, by adjustment when the engine is not running, of being extended any amount to ⅝ stroke. The valves will be wide open at 1-10 stroke, and the port opening is 12% of the piston area. The high pressure valves only are to be connected with the governor, and dash pots are to be used on this cylinder and closed by steam.

The speed of the surface of the shaft journals being great, the bearings were made sufficiently long to reduce the pressure per unit of surface considerably below that occurring in common practice, and ring oiling is to be employed. The product of journal speed by pressure per unit of surface, however, is far within that common in locomotive driving axle practice.

HEAVY TANK LOCOMOTIVE FOR THE MADISON INCLINE, PENNSYLVANIA LINES.

The operation on a grade of nearly 6%, more than a mile long, of the regular traffic of an important trunk line of railway is a problem not often met with, but such a grade exists near Madison, Ind., on the Louisville Division of the Pittsburg, Cincinnati, Chicago & St. Louis Ry. (the Southwest System of the Pennsylvania Lines West of Pittsburg). It is 7,012 ft. long, with a total elevation of 413 ft., making a rise of 311 ft. per mile, or approximately 5.9%. It is undoubtedly one of the steepest long grades in the world upon which a regular passenger and freight service is maintained with the use of adhesive power only. We illustrate herewith a locomotive designed specially for service on this very heavy grade.

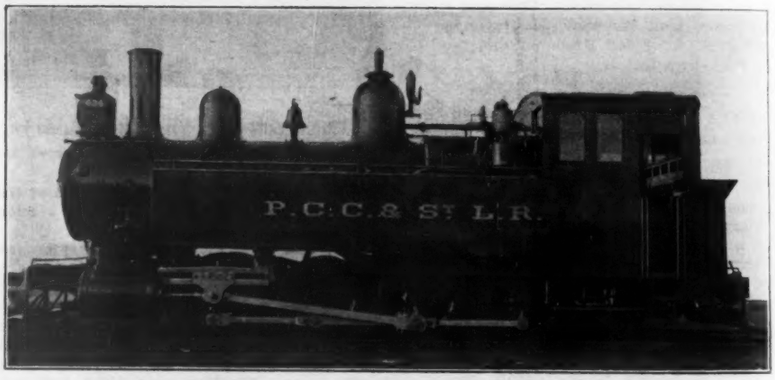
When ascending this grade, the cars (as a precaution in case of broken couplings) are pushed before the engine; and when descending, the engine backs down at the front of the train. It is to be understood that the regular road engines are disconnected from their trains at the top of the grade, and left there waiting for the next train brought up by the hill engine. The peculiar conditions of the service at this place necessitated many departures from customary locomotive construction, and the proportions of the engine are consequently somewhat different from ordinary practice and do not entirely conform to the rules recommended by the Master Mechanics' Association. One of the most notable features is the adoption of a tank engine, thus increasing the weight available for adhesion, a matter to which we have briefly referred on our editorial page.

The locomotive, as will be seen by the accompanying cut, is carried on eight wheels, all of which are coupled, and has a large tank on each side of the boiler and a small coal bunker behind the cab. The fuel used is bituminous coal. The general dimensions and particulars are as follows:

Tank Engine for Madison Incline: P., C., C. & St. L. Ry.

Running Gear:	
Driving wheels, diameter	4 ft. 2 ins.
Journals, driving axles	8 × 8½ "
Wheel Base.—Driving	15 ft. 3 "
Wheels having blind tires	Second pair.
Weight in Working Order; (all on drvg wh'ls)	**140,000 lbs.**
Cylinders	22 × 28 ins.
Distance center to center	4 ft. 4 "
Form of crosshead and guides, Laird (cast-st'l)	cross-h'd)
Connecting rod, length between centers	6 ft. 10⅝ ins.
Valve Gear:	
Type	Stephenson link.
Steam ports	18 ins.
Exhaust ports	18 "
Slide valves	Richards' balanced.
Lap, outside	1-in.
Lap, inside	3-16-in.
Travel	5 ins.
Lead	1-16-in.
Boiler:	
Diameter of barrel inside	5 ft.
Thickness of barrel plates	7-16-in.
Height from rail to center line	9 ft. 6 ins.
Working steam pressure	150 lbs.
Firebox:	
Type	Belpaire.
Length inside	7 ft. 9½ ins.
Width inside, at top	3 " 11½ "
Width inside, at bottom	3 " 6 "
Depth	4 " 9½ "
Thickness of side plates	5-16-in.
Crown sheet	⅜-in.
Tube sheet	⅜-in.
Grate area	27 sq. ft.
Tubes:	
Number	219
Pitch	2 15-16 ins.
Diameter, outside	2 "
Length between tube plates	13 ft. 4⅜ "
Total fire area of tube openings	3.65 sq. ft.
Heating Surface:	
Ratio to grate area	61.91 to 1
Tubes, exterior	1,528.80 sq ft.
Firebox	142.80 " "
Total, with exterior tube area	1,671.75 " "
Miscellaneous:	
Exhaust nozzle, single: diameter	5 ins.
Smokestack, smallest diameter	18 "
Smokestack, height from rail to top	15 ft.
Capacity of tanks	2,000 gallons.
Capacity of coal space	5,000 lbs.
Tractive force per lb. effective press. on piston	271 lbs.
Total tractive force with effective pressure equal to 30% of boiler pressure	32,520 "
Total adhesive tractive power, at 25% of weight on drivers	35,000 "

In order to prevent the trains from gaining too much headway during the descent the engine is equipped with an interesting arrangement for regulating the speed. This is based on the principal of the Le Chatelier brake, and is in some respects similar to that used on several of the western mountain railways. It consists in connecting the valve chests with a 1½-in. pipe, from which a 2-in. connection runs back to a point below the cab floor at the engineman's side, where it terminates in a muffler. When descending the hill the link motion of the engine is reversed, so that the cylinders during a portion of the stroke will force air up into the valve chests and thence through this pipe to the muffler, where it escapes into the atmosphere. By means of a regulating valve below the cab floor the escape of the air can be checked so as to obtain the most desirable speed for the pistons, and consequently for the engine. By closing the valve entirely the engine can be stopped during the descent. In order to prevent the pistons from sucking in air from the smoke box, with accompanying cinders and grit, a steam jet is directed upwards through the exhaust column from an opening in the hollow wall dividing the two exhaust passages. Fresh, clean air is instead admitted into the cylinders from a connection at the base of the exhaust column; this leads to the outside of the smoke box and is shown over the valve chest in the illustration. This connection can be opened or closed by means of a valve operated from the cab, and it is, of course, apparent that it must be opened only



HEAVY TANK LOCOMOTIVE FOR THE MADISON INCLINE; PITTSBURG, CINCINNATI, CHICAGO & ST. LOUIS RY.
S. P. Bush, Superintendent of Motive Power.

when descending the grade. In order to lubricate the cylinders a small jet of hot water is let into each exhaust passage. Besides this regulating device the engine is equipped with the American driving-wheel brake, and there is also a powerful screw hand-brake which alone will hold the engine and train on the grade.

As before stated, the service for which the engine was designed necessitated a departure from the customary proportions of locomotives. A little reflection will show how different the work of this engine is from that of ordinary engines. A road engine has to exercise its entire hauling capacity only when starting a train and getting up speed, but during the majority of the time it is in service only a fraction of the total power is needed. The total adhesive weight on the drivers is never utilized when the train is running at its regular speed with the lever hooked up towards the middle, and it is then that the economy of expansion comes in. If a road engine could be so situated as to have to make a continuous start lasting during its whole run, it would be under the same conditions as when going up a steep grade. The exertion of the full adhesive power is consequently not the exception but the normal condition of work on the Madison hill.

To use steam expansively under these conditions would be impossible, unless the cylinders were of much greater proportions with regard to the adhesive weight, than on the ordinary road engine. The total weight of the new engine is 140,000 lbs., all adhesive weight, but the mean weight during the ascent is about 130,000 lbs., this being based on the consumption of two-thirds of the water in the side tanks. According to ordinary practice this weight would require a cylinder proportion of about $22 \times 24\frac{3}{4}$ ins. The additional $3\frac{1}{4}$ ins. of the stroke which this engine has, is a clear gain in the expansion of the steam, over and above that which may be produced when the engine does not exert its full adhesive power up to the slipping point. In other words, the cylinders were made as large as it was practical to make them, and the economy of this is shown by the fact that ordinarily the engine is able to make three round trips up and down the hill without refilling its coal bunker, which holds only $1\frac{1}{2}$ tons of coal.

The engine was placed in service on Jan. 1, 1896, and has been giving entire satisfaction ever since. No official test of its hauling capacity has yet been made, although it is the intention to make such a test in the near future, in order to obtain reliable details of performance for comparison and future use. We are officially informed, however, that the engine has fully met the expectations of the officials, and that its performance during the ascent as well as the descent is entirely satisfactory.

Quite a number of interesting details had to be considered in the design of the engine. In order to keep the front ends of the top row of flues under water on the grade without filling the boiler so full as to cause the engine to get wet steam and throw water from the smokestack, the back end of the boiler is set considerably higher than the front end. The throttle valve is of the ordinary balanced type, but it has no play on its stem, the object being to avoid the clattering of the valve upon its seat in case the compression in the steam chest should exceed the boiler pressure during the descent. To protect the steam chests, a relief valve has been placed on each, which is set just beyond boiler pressure. In arranging the driving springs for the engine it was calculated that the front springs would receive the greatest load and they were designed accordingly. When the engine is on the grade, however, its center of gravity is shifted backwards, and in consequence the rear springs receive the greatest load, which caused some little inconvenience at first, until the necessary adjustment was made.

Instead of metallic piston rod packing, asbestos cord is used, as the metallic packing would be apt to be damaged when the engine is drifting down the hill without steam. The engine is equipped with pneumatic bell ringer, pneumatic sand valves, steam heat for passenger trains, and all modern improvements.

This locomotive was designed by Mr. S. P. Bush, Superintendent of Motive Power of the Southwest System, Pennsylvania Lines West of Pittsburg, and it was built at the company's shops at Columbus, O. We are indebted to Mr. Bush for the photograph and information used in the preparation of this article.

The city of Madison, Ind., is 85 miles southeast of Indianapolis, on the Ohio River. The inclined plane was built by the State of Indiana when Madison was on the transportation highway to the West. Passengers and freight came from the East over the old Portage road and the Johnstown canal to Pittsburg, thence on the Ohio River to Madison, thence through Indianapolis to central Indiana and Illinois. A portion of the plane is cut through solid rock over 100 ft. in depth, and there are two embankments nearly 100 ft. high. The incline plane was commenced in 1836 and finished in 1841. It came into the possession of the Pennsylvania System in 1874. The plane was finished in 1841 and operated by horse power until November, 1848. Andrew Cathcart's improved engine, having two sets of cylinders, and a pinion working in a rack in the center of the track, was used until July, 1868, when it was superseded by a more powerful engine designed by Mr. Reuben Wells, the Master Mechanic on the Jeffersonville, Madison & Indianapolis R. R., and built in the railway company's shops at Jeffersonville, Ind.

This old engine, which was in use until the present year, had eight driving wheels, 44 ins. diameter; cylinders, 20×24 ins.; wheelbase, 16 ft.; and weighed 57 tons. The boiler had a crown-bar firebox for burning wood, and carried a working pressure of 125 lbs. It was originally built with ten driving wheels, but one pair was taken off in 1886 to facilitate running over the sharp curves in the yards at Madison.

THE AMERICANIZING OF ENGLISH RAILWAYS.

A great deal has been done in the past few years in the introduction into Great Britain of features of railway practice which are practically copied from this country; and the results have been highly pleasing to the travelling public at least. Nevertheless the well-known conservatism of the Britisher makes itself heard occasionally in denunciation of these innovations. In a recent number the London "Engineer" publishes in its correspondence department a letter from a representative of this class which is most amusing for its bluntness and for the "Americo-phobia" (if we may coin a word) which its writer discloses. It will be noted that the writer, like many of his countrymen, considers that anything of old establishment must be good, and he deprecates the use of the improved American car coupler because the clumsy English coupler has been in use for 60 years. It is also to be noted that side-chains are used with the American automatic coupler for passenger cars, and it may be inferred that the writer of the letter is not very well posted on the details or merits of the devices which he criticises.

We print the letter in full as follows:

Sir: From time to time efforts are made by various well-meaning people to Americanize our English railways, apparently under the impression that whatever is American is right, and that we do not at all understand what suits us best. Differences of climate, of average length of journey, and of long custom are taken little into account by these zealous reformers, who are quite convinced that whatever pleases the American traveller ought to give equal satisfaction here. One of these periodical waves of Transatlantic influence is now passing over this country, and no doubt, like former ones, will leave some traces of its passage. We are promised the Brown coupler, the Jones "car" heater, the Robinson lighting apparatus and what not. Because Americans are content to stew themselves in winter time at 80° at the pleasure of a black attendant, who naturally loves tropical temperatures, we ought to do the same. It is stated that the Great Western Railway, with more zeal than patriotism, is ordering steam heating apparatus from America. The steam heating, to my thinking, is both unpleasant and ridiculously unnecessary in this country. What need has there been for it during the last winter for example, when not a flake of snow or a piece of ice that would bear a dog was seen? It dries rather than warms, and brings the dampness out of wet clothes, boots, and umbrellas in a most unwholesome manner.

Another great fad of the Americanizers is that a system of coupling which has answered its purpose admirably well for sixty years should be given up for a clumsy lump of metal, which can only act by the coaches being heavily bumped against each other, and which, if it should give way, has no side chains to keep the train together. Our permanent way, the best in the world for solidity and excellence, for convenience of renewals and for durability of parts, must be abandoned for one in which the rails are fastened down with dog spikes, after the manner of contractors' temporary lines, and have nothing else to prevent them from turning over. Wood being so cheap in America that the railways can afford to almost pave their lines with roughly hewn logs, we ought in this country, where every sleeper is imported, carefully selected, dressed to a standard size, and preserved by chemical means, to make our lines a continuous wooden flooring. No proof that English railways use too few sleepers is given, but American ones use more, which, of course, quite settles the question.

Our system of conveying passengers' luggage is found to be entirely wrong by the admirers of American practice. The system of checks is all very well for long journeys of two or three days' duration, but what advantages has it for those of as many hours? It is based mainly also upon the plan of having luggage conveyed to and from the stations indeperdently of the traveller it belongs to, a system which does not obtain here, and is not the least likely to.

Even the late regrettable outrage on the Brighton Railway is turned to account by the foes of our comfortable and cosy system of compartment coaches. If we travel in huge caravans, full of draughts and smells, dust and noise, such things, it is said, could not happen. About a thousand millions of passenger journeys are made annually in this country, and such a case occurs perhaps once in five or six years. Can any American say the same for the United States? Of course we do not over here know of every outrage which occurs in American trains, but shall need a good deal of convincing that they can possibly be rarer under any system than they are in Great Britain.

In America, where many journeys run to 2,000 miles, and even a good deal more, and where passenger traffic is of much less importance than goods, it may be necessary to induce people to undergo the fatigue of such journeys by affording them far more luxury in travelling than the vast majority ever get at home. But is it really required here, where a journey of 300 miles is considered a good day's work by most people? Are these novelties in the least demanded by the British travelling public, or are they simply forced upon it by the reckless competition between the companies? I freely admit that a good deal has been copied in this country from American practice during the last few years, and with advantage; but where is the process to stop? One of the most serious aspects of the question is that concerning the enormous deadweight per passenger of the American style of coach. The latest trains of this type, just built for the East Coast joint service to Scotland, weigh 270 tons and carry 300 passengers, or 2,016 lbs. per passenger. A train of six-wheeled stock, quite as safe and amply good enough for any one not enervated by luxury he never originally wanted, could carry as many and weigh only 90 tons, including a 12-ton van. As to lunching or dining in trains, it is simply so much money taken away from the station refreshment rooms and maintaining extra staffs to do it with. To most Englishmen it is far more agreeable to leave the train for a few minutes now and then to obtain necessary refreshment, than to take it amidst the noise and vibration of even the most gorgeous dining saloon ever put upon wheels. The fact is, many English railways are so prosperous just now that they hardly care what expense they go to in order to eclipse their rivals, whether in speed or luxury. They think nothing of using a couple of enormous engines and tenders to convey two or three dozen passengers at a break-neck speed in 25-ton vehicles costing $10,000 apiece. I very much fear that when hard times come again—and they always do come again and generally stay longer than is convenient—and the companies find people have been made dissatisfied with the comfortable and profitable English coach, they will regret the necessity for building more and more of these travelling drawing-rooms, dining-rooms, bedrooms, smoking-rooms, kitchens, lavatories, and heaven only knows what. They need not think to confine them only to the very longest journeys; passengers will want them on much shorter runs, and I shall be surprised if the companies are loyal enough to each other to hold out unitedly against such a demand.

W. B. Paley.

September 8th, 1896.

A PORTABLE ASPHALT PLANT has been built by the Hetherington & Berner Co., of Indianapolis, for the purpose of preparing asphalt for paving work in small cities where it would not pay to erect a stationary plant. The apparatus consists of two cars having steel frames and corrugated iron sheathing. Packed in one of these is a frame made of tubing and light steel beams, which forms the framework for the machinery when the plant is in use. The cars are run on a sidetrack and have the wheels blocked, the framework is erected and the mixer mounted in position on a tower between the cars. One car carries the power plant, consisting of a locomotive boiler and a steam engine. This car also contains the sand dryer and screens, while the other contains the asphalt kettles.

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The uncoupling of M. C. B. couplers while trains are running, without any evident reason for the action, forms the subject of some interesting figures recently made public by Mr. J. N. Barr, Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul Ry. According to this statement and to similar statements by other railway officers, these accidents are becoming frequent enough to demand the study of motive power officials and coupler manufacturers to provide a remedy. Mr. Barr's records cover a period of two years, but he presents actual figures for only two months of the period, viz., the months of August and September, 1896. These are as follows:

Causes of Train Break-in-Twos with M. C. B. Couplers.

August.		September.	
Chain too short	3	Chain too short	1
Locking block worn	1	Locking pin worn	3
Locking pin raised	1	Locking pin raised	6
Undetermined	21	Wrong knuckle	1
		Guard arm too open	1
Total	26	Undetermined	24
		Total	36

It will be seen that out of 62 uncoupling accidents occurring during the two months designated, 45 occurred without any apparent reason as far as an examination of the coupler or the observation of the trainmen gave evidence. Mr. Barr states further that the accidents were no more frequent with one make of coupler than with another, and also that as far as his observation gave evidence the uncoupling was not due to the sliding free of the knuckles without opening. As an explanation he suggested the possibility of the "creeping" of the locking device until it finally raised sufficiently to free the knuckle, which was then pulled open. This uncoupling of automatic couplers was one of the subjects discussed at the convention of the Master Car Builders' Association in June last, as recorded in our issue of June 25, and it appears that this is a trouble which is being experienced on many railways, and Mr. Barr himself stated in his remarks that the partings of freight trains by unlocking of M. C. B. couplers were four times as numerous as those from breakages of link-and-pin couplers. The general trend of the discussion appeared to show that the trouble is mainly due to the locking pin, which is caused to rise by the jarring or buffing strains or by the nipping action of the knuckle incident to the motion of the cars. The collecting of coal and dirt under the pin, and the use of too short a chain on the pin were also adduced as reasons for this very undesirable action. It would seem to be necessary for coupler manufacturers to look very closely into this matter and to discuss it with the men who are familiar with the use of the cars in actual service, so that some means may be adopted to prevent these dangerous break-in-twos. From the evidence thus far presented, it would seem that gravity alone is not a sufficient reliance to hold a knuckle lock in place, and that the lock ought to be held in its place by some mechanical connection when the knuckle is closed.

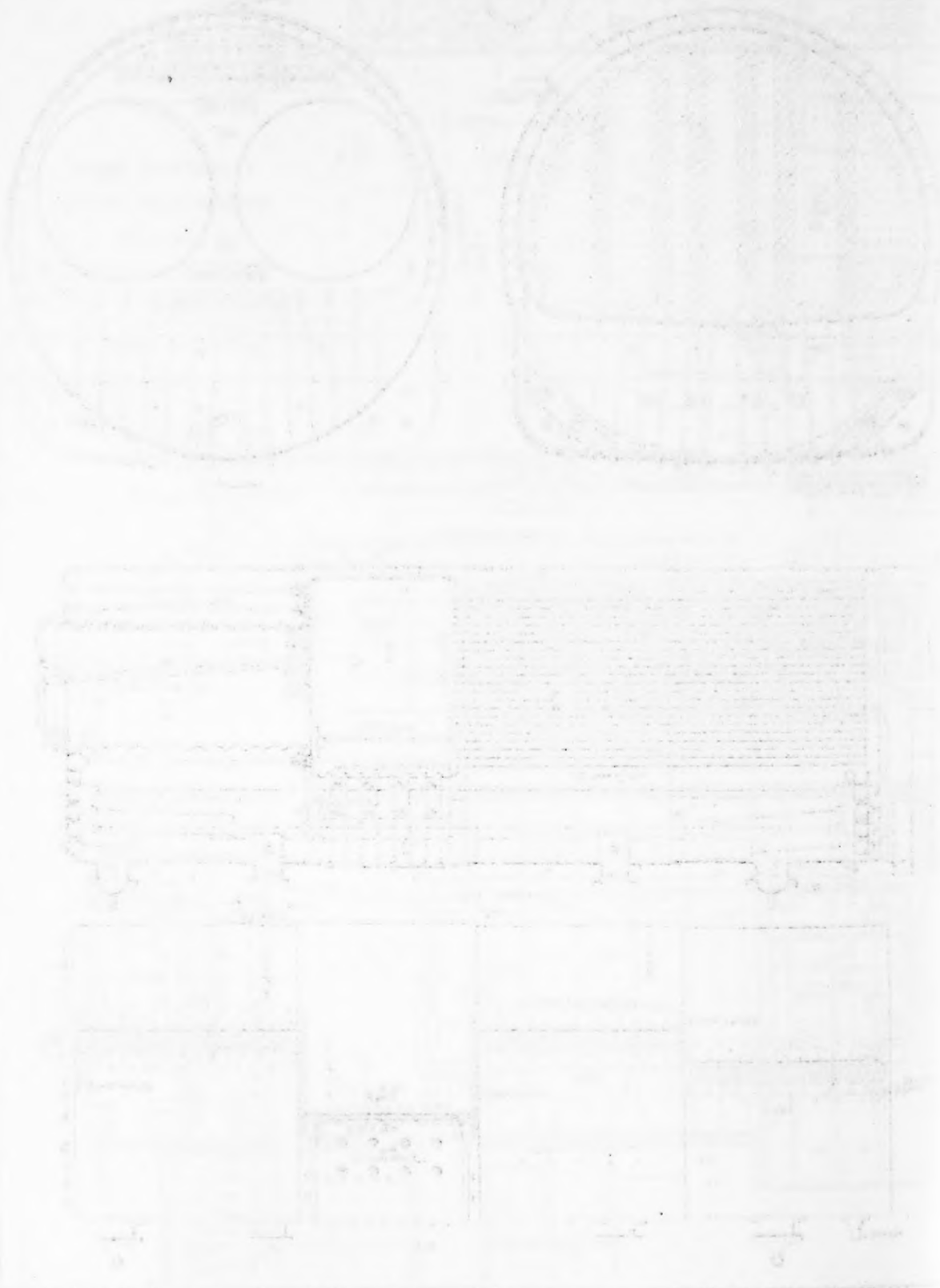
The advantages which tank locomotives possess for certain classes of service do not seem to be as generally recognized as they should be by American railway managers and superintendents of motive power. The advantages of such engines for yard service are pretty well known, though engines of this type are but little used in practice even for this purpose, but their advantages for a suburban service where frequent stops are required deserve to be better known. It is to be remembered that a tank engine saves the cost of a tender, and occupies less space on the track, which latter is an important consideration in yards. In yard work, also, the tank engine gives the engineman a good view to the rear, so that he can handle his engine in such a way as to do little injury to cars in switching. The New York, Pennsylvania & Ohio R. R. (Erie R. R. system) and the West Shore R. R. are among the few roads using tank engines for yard work, and the Long Island R. R. is one of the few using engines of this type for suburban service. All elevated railways operated by steam, however, are equipped with this type of engine exclusively. The Grand Trunk Ry. (following English precedents in this as in many other matters) uses tank engines for both the above classes of service, and the traffic in its St. Clair tunnel is operated by monster tank engines mounted on ten wheels (all coupled).

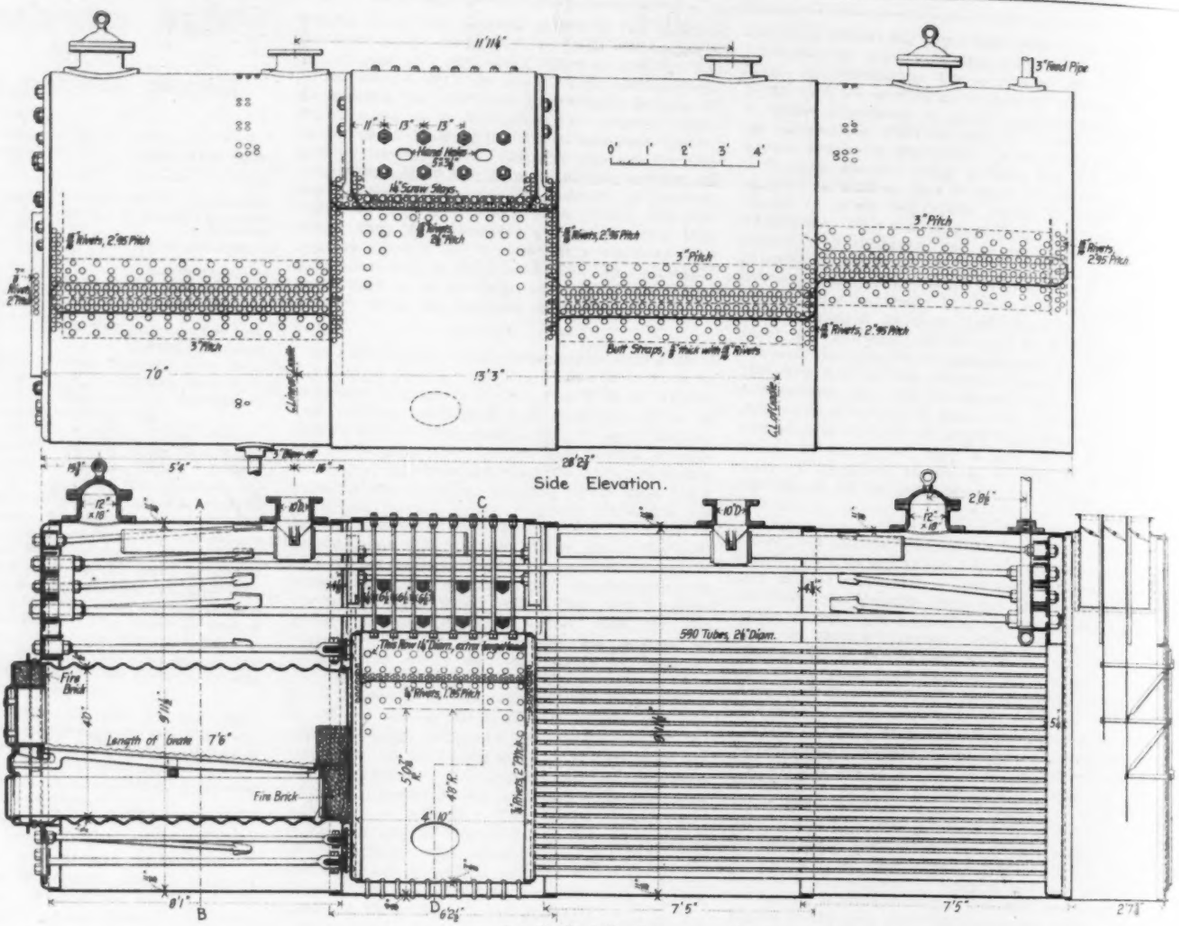
In this issue we illustrate and describe a new and powerful tank engine built for working the heavy passenger and freight traffic over the Madison incline on the Pittsburg, Cincinnati, Chicago & St. Louis Ry. Here the run is short, with no trouble in taking coal, and all the adhesive weight than can be obtained is desirable, while the amount of switching required makes the shortness of the engine an added advantage. In England, tank engines of various types are used almost exclusively for suburban and switching service, and we have from time to time illustrated some of these locomotives. While the new engine described elsewhere is for special service only, and cannot be taken as an indication of any intention towards a general use of such engines, it at least serves to call attention to the tank type of locomotive, and may lead to some further consideration of the advantages of this type for other classes of work.

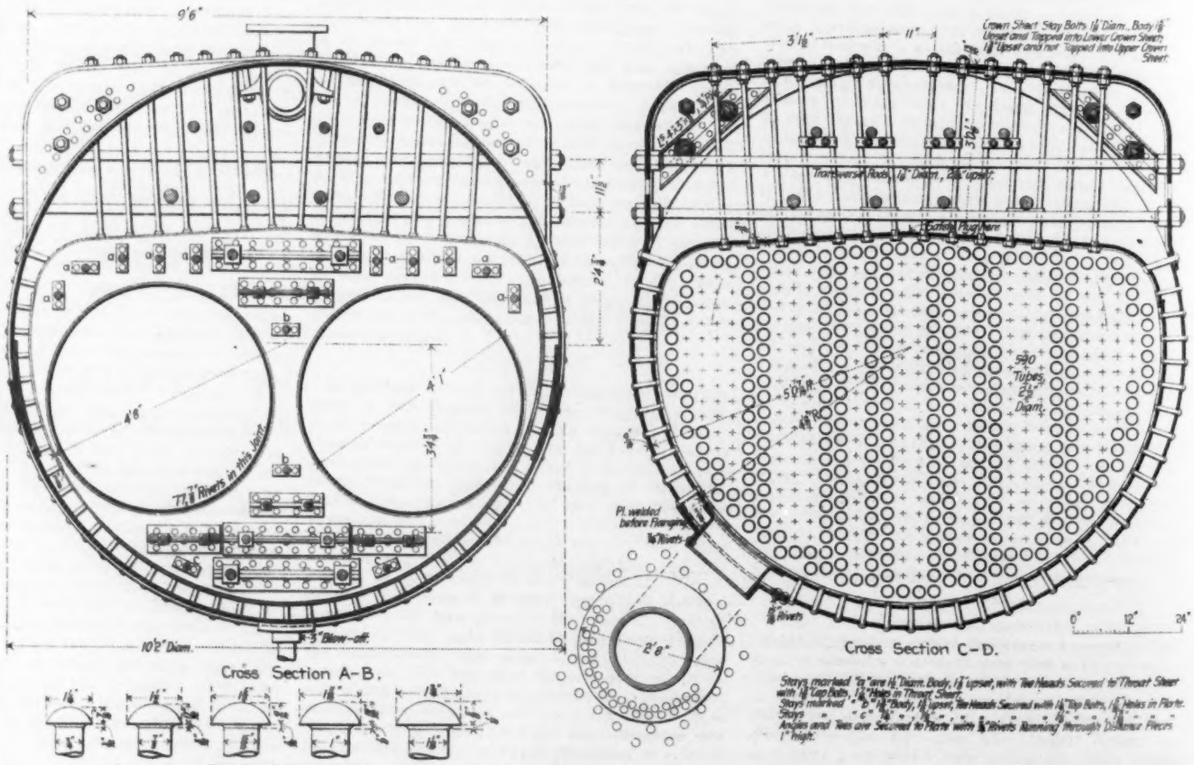
In his late annual report, Commodore Melville, Chief of the Bureau of Steam Engineering, directs especial attention to the number of engineer officers of the navy who have been retired during the past year for physical incapacity, and to the steadily increasing number of such officers on the retired list. He says that these retirements are conclusive proof that the physical strain to which the officers of the engineer corps are now subjected is too great, and that the only remedy is an increase in the number of such officers. Commodore Melville takes the position long held by this journal—that in the modern battleship "the guns would be powerless without the machinery; also that, other things being equal, that fleet will give the best account of itself which has the best equipment of trained men in the engine room, as well as at the guns." It is to be sincerely hoped that the next Congress will handle this subject of naval personnel in a business-like, intelligent and thoroughly unprejudiced manner; and in the spirit that the real importance of the subject demands. Our Government has been liberal for some time past in its appropriations for new warships, and the results of these appropriations are a source of national pride, and are serving as models for nations with a longer experience in naval construction. But, as Commodore Melville says, it is one thing to design and build machinery for these vessels, but it is quite another thing to keep this machinery in such condition that it may be ready to respond to every call made upon it under all conditions. This naval machinery is of such a complicated character and of such common and diversified use that constant vigilance and the greatest care are necessary to keep it in the state of efficiency required. If the number of trained men demanded by these conditions is not sufficient, the efficiency of the ship as a fighting or cruising machine is correspondingly lowered and the skill and money expended upon her design and construction are practically wasted. In our new navy a sufficient number of trained officers and men is of quite as much importance as new ships. If we are to have a new navy it is the duty of Congress to see to it that it is made efficient in all its branches.

That old familiar subject for discussion, the respective merits of bridges having pin connections and riveted connections, has been left in peace for some considerable time, but was brought out again at last week's meeting of the American Society of Civil Engineers. The occasion was a brief paper by Mr. George E. Gray, Hon. M. Am. Soc. C. E., referring to old riveted bridges on the New York Central R. R., and the advantages of this type of truss were ably set forth in the discussion by Mr. George H. Thomson, who is well known as an advocate of this type of construction. The greater safety in case of a derailment on the bridge was, of course, put forward, but, on the other hand, another member considered that the fact of the far greater number of pin-connected bridges made impossible any proper comparison on this ground. He instanced some severe cases in which pin-connected bridges had successfully withstood serious damage, and yet had not collapsed in the way that the opponents of this type of construction had claimed that they would (or at least ought to) collapse. The advantage of distributing the load over a great number of points were touched upon, but curiously enough no reference was made to the multiple-intersection latticed construction in which this feature reaches its highest development. The discussion turned almost entirely upon ordinary through trusses having riveted or pin-connected members, but even Mr. Thomson admitted the applicability of the latter system for deck structures. There was not a very long or comprehensive discussion, nor did it bring out anything very new, beyond the facts of the extent to which riveted truss bridges with solid floors have been introduced on the Central Vermont R. R., and it was really but a brief revival of an old but interesting subject. It may be noted, however, that the portals of the Central Vermont R. R. bridges are distressingly ugly from an aesthetic point of view. The heavy rectangular end-posts are connected by a rectangular portal girder with triangular gusset plate connections of the girder to the posts. Considering the amount of money expended in getting a good design and a good structure, a little money might surely have been spent in securing a less harsh and unsightly treatment. An arched portal girder, or curved gusset plates would have had a lighter and pleasanter appearance, without in any way reducing the strength of these important members. It is evident that bridge engineers, as a class, have not yet began to realize the demand for some regard for aesthetic principles in their structures.

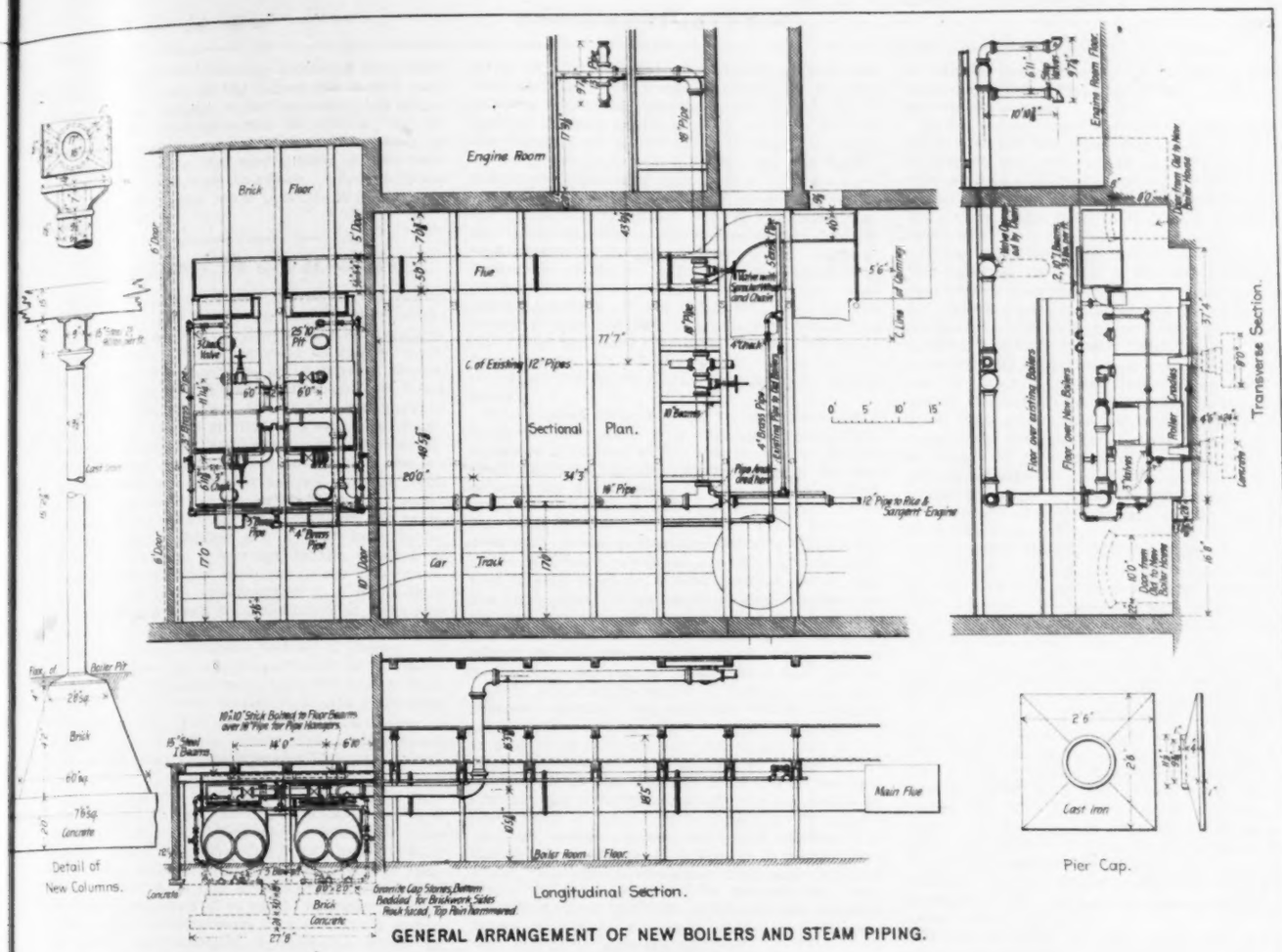
There is one matter in connection with pin-connected bridges, which especially deserves to be kept in mind by engineers, and that is the advantage which they possess with respect to erection in difficult localities. On the inset sheet in our last issue was a view of a great bridge on the Trans-Siberian Ry. over the Usuri River, a structure with three long spans all made with riveted trusses. The labor required to prepare the material for such a bridge, transport it to the site and erect it, must have been enormous; and the



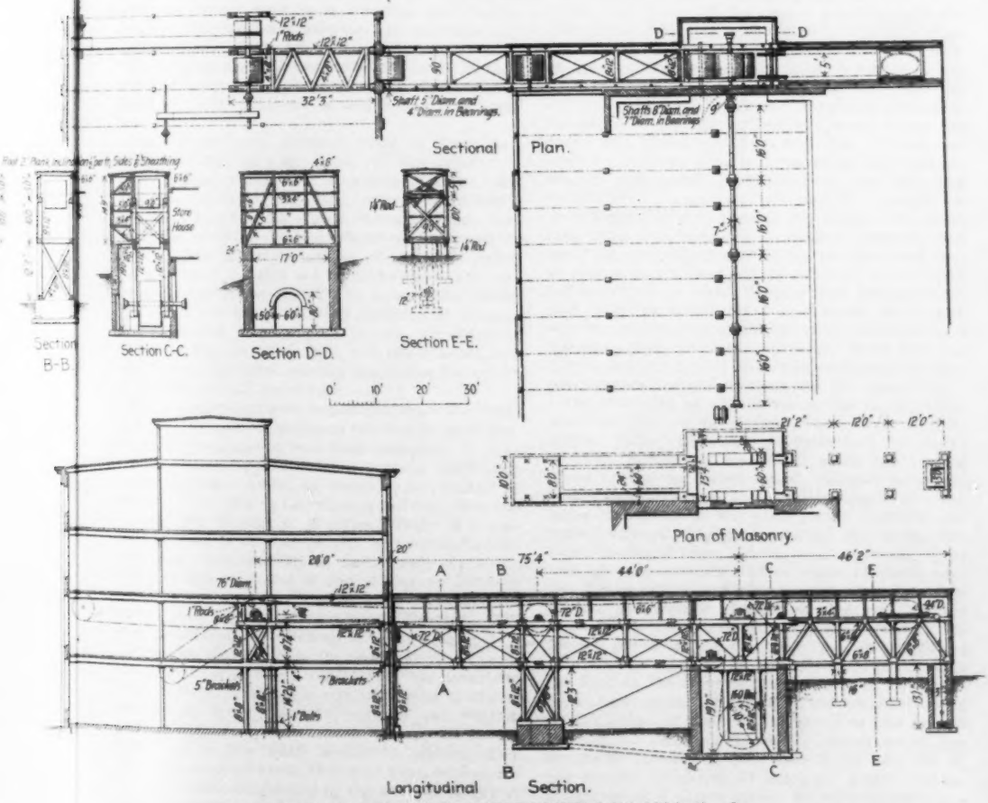



9'6"
10'2" Diam.
3" Blow-off
Cross Section A-B.
Crown Sheet Stay Bolts 1⅛" Diam., Body 1⅛" Upset and Tapped into Lower Crown Sheet, 1" Upset and not Tapped into Upper Crown Sheet.
Transverse Rods, ⅞" Diam., 22½" apart.
Section A-A.
Section B-B.
590 Tubes, 2¼" Diam.
Pl. welded before Flanging
⅝" Rivets
2'6"
Cross Section C-D.
Details of Rivet Heads.
Stays marked "a" are 1⅛" Diam. Body, 1⅛" Upset, with Toe Heads Secured to Throat Sheet with 1⅛" Cap Bolts, 1¼" Holes in Throat Sheet.
Stays marked "b" 1⅛" Body, 1⅛" Upset, Toe Heads Secured with 1¼" Cap Bolts, 1⅛" Holes in Plate.
Stays " "c" " " " " " " " " " " "
Angles and Ties are Secured to Plate with ⅞" Rivets Running through Distance Pieces 1" high.

TWO-FURNACE BOILER, LOCOMOTIVE TYPE.



GENERAL ARRANGEMENT OF NEW BOILERS AND STEAM PIPING.

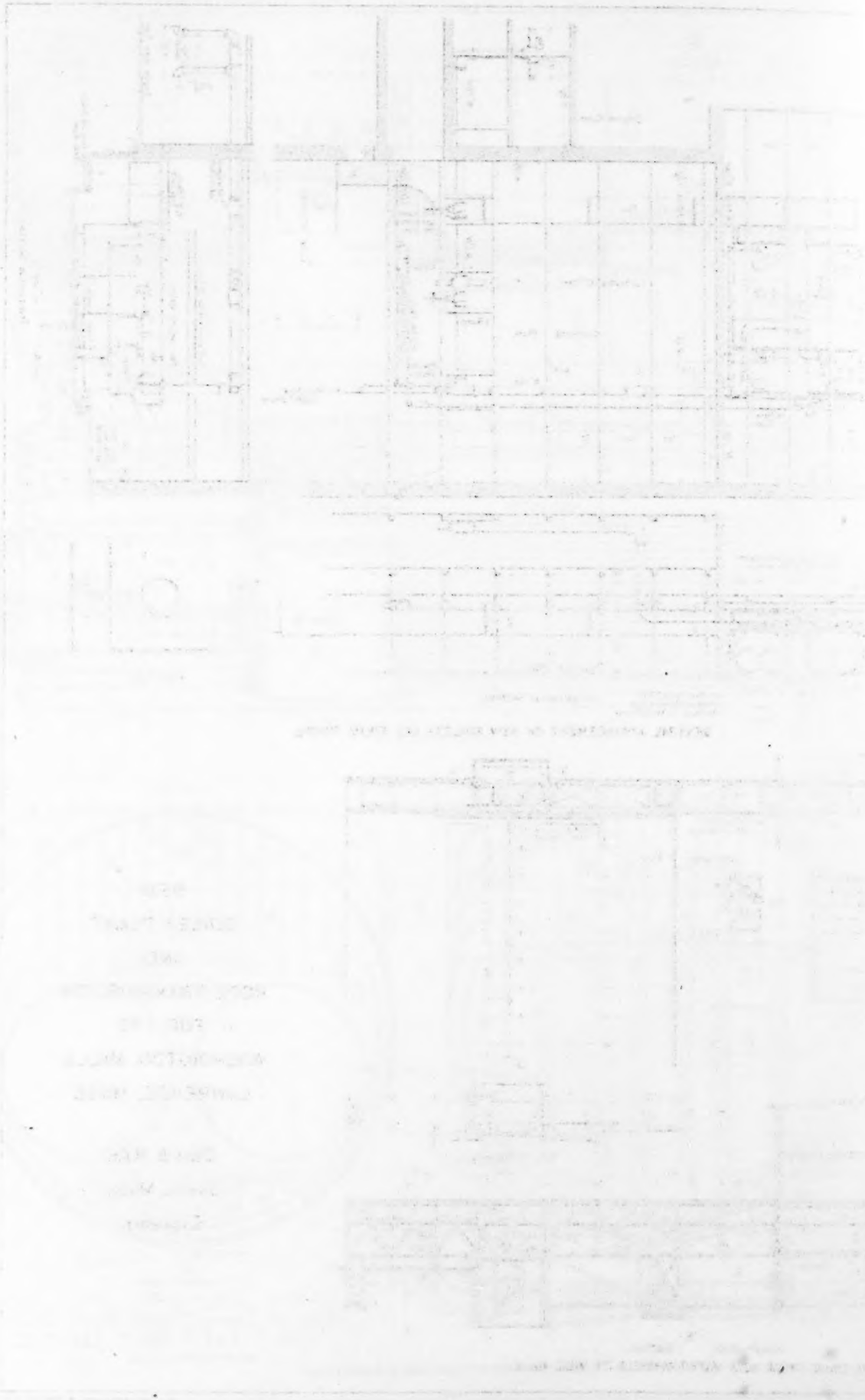


ROPE DRIVE FROM NEW WATER-WHEELS TO MILL No. 5.

NEW BOILER PLANT AND ROPE TRANSMISSION FOR THE WASHINGTON MILLS, LAWRENCE, MASS.

Dean & Main,
Boston, Mass.,
Engineers.

CHAS. HART & SONS, LITH., 29 VESEY ST., N. Y.



vast amount of field riveting necessary must have kept the structure on the falseworks a very long time. The advantage of the pin-connected structure for any such situation is obvious to an American engineer. Apparently the builders of the Trans-Siberian Ry., and similar pioneer railways, could patronize American bridge companies or at least copy their practice with a great deal of profit.

HIGH BUILDINGS AND SAFE ELEVATORS.

To the European traveler in the United States at the present day there is probably no more striking feature than the prevalence of high buildings in large cities. We do not refer by this so much to the wonderful structures of 16 or more stories, of which both New York and Chicago can boast a considerable number, but to the buildings of eight, ten or twelve stories, of which great numbers exist in all our large cities, such as Philadelphia, Boston, and St. Louis, and which are becoming quite a prominent feature even in such minor cities as Pittsburg or Buffalo. The social and economic results which come from the prevalence of high buildings are of great importance. It is of enormous advantage in the conduct of business, for example, enabling a very great number of people to be concentrated in a small area, and yet giving them an abundance of light and air, and room for convenient work. Take for example the central business district of Chicago. If all the business in this district were to be transferred to buildings not more than five stories high, it would be necessary to cover an area more than twice as great. The added difficulty and cost of carrying on business when such an extended area is included in the business district are evident.

For an example on the other side we may take the city of London. As is well known, the area which the old city of London covered, now commonly known as "The City," is almost wholly given up to business; but the vast amount of business transacted on this limited area coupled with existing restrictions as to height of buildings (few office buildings being more than five or six stories in height) has compelled a crowding which an American would find most irksome and inconvenient. The contrast between the spacious and well lit offices of an American firm in a modern office building and the cramped and dimly lighted quarters which satisfy a London firm doing a similar amount of business, is one which has often been noted.

Now, while rigid building laws in European cities are partially responsible for the absence of high buildings there, it is also true that the high buildings of American cities are made possible only by a notable American invention, the fast passenger elevator. Its development has been as rapid as has the development of the high building itself, and had this not been the case, it is certain that the latter would not have taken place. We should not see a 30-story building in process of construction in New York to-day, for example, if the elevator builders had not made great advances over the slow moving machines that were in common use 15 years ago.

But a matter not less important than the features of speed and reliability is the matter of safety. It is only because it has been possible to convey passengers up and down a vertical shaft with almost, perhaps quite, as small a percentage of casualty as occurs in travel on a railway, that the elevator has become so popular. There is a sensation of risk in moving swiftly up or down a vertical shaft, and only habit and experience of its safety dispels it. But if once a serious accident occurs to an elevator, fears are aroused, people resort to stair climbing and tenants begin to look with more favor on buildings of lower height.

From this point of view the recent accident to an elevator in the 22-story building of the American Tract Society, reported in our last issue, is of importance to every one interested in any way in high buildings, or their construction. It would take only a few such accidents, should they chance to occur at about the same time, to seriously shake public confidence in the general safety of elevator service; and should this take place, the investment in present high buildings and the construction of additional ones might be seriously affected. In other words, it behooves elevator builders and those responsible for the safety of existing elevator plants to spare no pains to keep the standard of safety at its highest, not only to make safe their own business, but the investments and business of thousands of others.

Reviewing now briefly the circumstances of the accident in the Tract Society building elevator, it appears that in the design of this plant, a high-pressure hydraulic system, using water at a pressure of 900 lbs. per sq. in., was adopted in place of the lower pressure, about 150 lbs., commonly employed. It will be apparent that by this means it was possible to materially reduce the size of the hydraulic cylinders, and thus the space taken up by the elevator plant. This was, of course, an important matter in so large an installation.

In published statements the builders ascribe the troubles which have been experienced with these elevators to the use of this system; but it appears doubtful to an engineer whether this is the sole or even the main reason for the accident.. Ever since these elevators were put into service there has been difficulty in operating them. With the best care on the part of the operators they have found it difficult to run the elevator cars smoothly and to stop them at a floor landing at exactly the right point. It can easily be believed that the valves controlling the movement of the hydraulic plungers were not so well proportioned as those which the builders had for years used on low-pressure work, and to which they were accustomed; but that is hardly a fault of the high-pressure system. An accident which occurred some months ago, in which a car dropped suddenly a story or two, we have heard ascribed to air in the cylinder, a danger against which every precaution should be taken in a hydraulic elevator system; but it is not apparent why air should be more likely to give trouble here than in a low-pressure system. Again, the recent accident was due to the breakage of a bolt in a check-valve cover; but unless the error was committed of using the same check-valves for 900 lbs. pressure that was used in ordinary low-pressure works, it is again not clear what the high-pressure had to do with the accident.

The real cause of the recent accident and the root of the difficulty with which all elevator engineers are now struggling is simply the great rate of speed at which elevators in high buildings are now required to be run. Recent specifications call for a speed of 700 ft. per minute on passenger elevators, or nearly 8 miles per hour, about the speed of a Broadway cable car. The elevator car with an average load and including its counterweight will weigh, perhaps, two tons, and this weight must be started from rest and brought up to full speed in a movement of perhaps 5 ft., must stop from full speed in a similar distance, and must be capable of control by the elevator boy, so that it can be stopped at the floor level within a fraction of an inch. Besides this, the acceleration and retardation must be suitably graduated, else the passengers will be forcibly reminded of a toboggan slide, when the car starts down, and will feel as if their avoirdupois had suddenly and uncomfortably increased when the car shoots up.

The difficulty of difficulties comes in, however, when we take up the design of the safety attachments. Every passenger elevator has, or ought to have, appliances by which, when the normal speed of the car is exceeded, whether from the breaking of the rope, the derangement of the elevator machinery or any other cause, clutches automatically grip the guides at the side of the elevator shaft and bring the car to a standstill. This was an easy enough matter when elevator cars ran 200 or 300 ft. per minute; but when we reach 700 ft. per minute difficulties thicken. There must be a considerable margin between the normal speed of the car, and that at which the safety clutches is set to operate, for variations in the load on the car and the pressure in the cylinders cause large variations in the ordinary speed of the cars. If the normal speed is 700 ft. per minute, we presume the safety clutch could not be set to operate at less than 1,100 or 1,200 ft. per minute, or nearly 12 miles per hour. But the operation of a safety clutch at such a speed is a thing to be done with caution. To bring a weight of two tons or so too suddenly to rest from such a velocity might cripple the elevator guides or cause some other breakage which would make a bad matter worse.

In the recent Tract Building elevator accident, the car did not fall. It merely ran down the shaft at a speed not high enough to operate the safety clutches and struck the buffers at the bottom. Its passengers found by experience that to be brought up with a shock from even such a speed is not unattended with danger.

It was a trifling thing that caused the accident. The breakage of a bolt in a check valve on the pipe leading from the pump to the hydraulic cylinder started a leak, which caused the movement of the plunger, just as if the discharge valve from the cylinder had been opened. But this leak was not automatically closed when the car neared the bottom of its shaft, as the valve would have been, and so the car struck the bottom buffers at full speed. Any other cause which would have started a leak from the cylinder and the system of piping to which it is connected would have been equally effective in causing the accident. In most of the newspaper accounts of the accident, in fact, it was ascribed to the blowing out of a gasket. It doubtless occurred to most engineers who saw these reports that it was a strange sort of engineering that used a gasket which could by any possibility blow out, for the joints of a hydraulic elevator system. We presume that metal to metal joints, or at least some form of metallic gasket is used for such connections.

Another fact of importance comes to light in considering this accident. Suppose that the break of this check-valve cover bolt had occurred a moment sooner, just when the elevator car was standing at a floor, and passengers were getting on or off it. The car would have instantly started down and the chances are great that one or more of the passengers would have been caught in the doorway and cut in two. This is a danger which does not seem to be guarded against as it should be in elevator construction. When the car is standing still it is held in position only by the elevator machine and any break or failure occurring at that time, if passengers are entering or leaving the car, may cause a fatal accident.

It may be urged that the chances are so remote of such an accident occurring that it is not worth while to make provision against it. There is a popular idea that an elevator is a machine so simple and safe that it is very little liable to accident or to getting out of order. In this connection we find some interesting figures in the last quarterly report of the Superintendent of the Department of Buildings of New York city. This department is by law charged with the duty of inspecting passenger elevators. We quote the summary of its work in this field in the first nine months of two successive years as follows:

	Jan. to Sept. —inclus.—	
	1895.	1896.
No. inspections of passenger elevators	2,632	4,257
Defective passenger elevators reported	62	856
Elevators made safe on notice from Dept.	44	912
Pass. elev. cases sent to att'y for prosecution	16	182

It is certainly clear from these figures that unless the present inspection is too severe by far, the inspection of a year ago was a highly incomplete and perfunctory affair. Further, the fact that the inspectors of the Building Department should be able to find an average of 95 defects a month in the passenger elevators of this city is surprising and somewhat disquieting. It must be remembered that an elevator plant ought to be and generally is in the charge of competent attendants, who should discover and remedy all defects, regardless of the occasional visits of the official inspector. In addition, a large number of elevators are regularly inspected by private firms who make a specialty of this work. It will also occur to many of our readers, doubtless, that the above figures show well that safety is not to be found in reliance upon any municipal or state bureau. If we grant that the inspection of 1896 was thorough and effective, what guarantee have we that we may not in a year or two return to the conditions of 1895?

Returning to our statement above that the real cause of present troubles with passenger elevators is the high speeds at which they are required to be run, we are far from saying that because of this fact present standards of speed should be low-

ered. The speed of 700 ft. per minute, which is the highest now in use so far as we recall, is no more than is actually needed to give sufficiently prompt service to buildings 14 or more stories in height. We do believe, however, that it is the duty of elevator makers, and of the engineers who specify the requirements which elevator makers must fill, to pay more attention to the matter of safety when such high speeds are required.

The most fruitful direction in which to work, it appears to us, is in connection with the safety devices on the car itself. We know of no good reason why every elevator car should not be furnished with a brake, under control of the operator, by which the car could be stopped and held at any point of its travel quite independent of the operating mechanism. If this brake were interlocked with the operating lever, or with some mechanism connected with the doors at the various landings, the car could be held absolutely in place at every stop and the danger of its starting up or down while passengers are entering or leaving, either through accident to the machinery or through the carelessness of the operator, would be wholly done away with. It may also be noted that the common annoyance of cars creeping up or down on account of minute leaks when standing at a floor would be obviated by such an appliance.

A word may be said here also concerning the provision of air cushions at the bottom of elevator shafts. These were in quite general use a dozen years ago, and many remarkable tests were made with them, such as dropping a car several stories without injury to passengers. With the advent of buildings of 12 stories and upward the air cushion idea appears to have been generally dropped. This, again, seems to us a mistake, for an air cushion is not designed to catch a car falling freely from a height of a half-dozen stories or more. Other appliances on the car should prevent any such great speed as would be obtained by a free fall from such a height. But an air cushion would serve a useful purpose in arresting a car which runs down the shaft as did the car in the Tract Society building without setting the safety clutches.

That the automatic clutch alone is not enough of a safeguard for high-speed elevator service, however, seems to be amply proved. Many of our readers will recollect in the Manufacturers' Building at the Columbian Exposition a set of hydraulic elevators which carried passengers up to the roof of the building, a dizzy height. During the exposition one of these elevators fell with a load of passengers on account of the breaking of the rope. The car fell several feet and then was stopped by the safety clutches, but these released as soon as the car stopped and again it fell, to be again brought up, and so on, till it came to a final stop some 20 ft. above the bottom of the shaft.

It is a well-known principle in the operation of safety devices of every sort, that unless provision is made for their regular use or testing, they are very apt to be out of order and inoperative when the emergency comes which they are designed to meet. This is an inherent fault of the ordinary safety attachment on an elevator car. In the regular course of events it is never used during the entire life of the elevator, and it is, therefore, never certainly known whether it will operate effectively when an accident occurs which it is designed to meet. This affords another reason why the plan of having the safety clutch operated by the elevator boy at every stop of the car would furnish additional safety as compared with the present system.

LETTERS TO THE EDITOR.

Early Bridge Trusses without Diagonals.

Sir: In your issue of Nov. 19 you refer to a bow-string truss bridge at Hoosick Falls, N. Y., which was constructed without diagonals or their equivalent, and remark that it is the only instance in your knowledge of such construction.

The Mosely Bridge Co., of Cincinnati, Ohio, built bow-string highway bridges at a very early date. This firm constructed one at Galena, Ill., in 1858, and one at Rush St., Chicago, at about the same time. These were swing bridges with an iron tower, and carried rods or hog chains, which suspended two bow-string trusses. These trusses had no diagonals, being constructed on the same principle as shown in your cut. The upper chord was triangular, consisting of three plates. Several of these bridges were constructed in Illinois, but they were stationary, with the exceptions noted. One was at Golconda, Pope Co., one at Clay City, Clay Co., and one on the Little Wabash, in Wayne Co. The latter was still in use three years ago, but all the others mentioned have either fallen or been taken down.

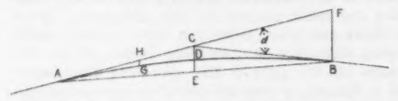
Yours truly,

Bloomington, Ill., Nov. 21, 1896. J. H. Burnham.

Vertical Curves for Connecting Railway Grades.

Sir: The accompanying table of corrections for grade elevations, to be used where vertical curves are used on railways in rounding off the angle formed by the junction of two grade lines, may be of interest as indicating a convenient method of tabulating corrections for any given difference of grades and length of curve desired.

The curve employed is the usual parabola, chosen because of the ease with which any correction may be found when the correction at the vertex, or meeting point of grade lines, is known. Two properties of the parabola are utilized; 1, that ordinates from tangent to curve vary as the square of the distance from the point of tangency; and, 2, that the curve bisects the vertical intercepted between the vertex and long chord joining the P. C. with the P. T.



Vertical Curves For Connecting Railway Grades.

In the figure let H G, = T, be the correction at distance x from A; M = C D, the correction at the vertex, and 2 L the length of the curve in stations, then the property first referred to gives the relation

$$T = M \frac{x^2}{L^2}. \qquad (1)$$

To find M, produce A C to F to meet a vertical through B, the end of curve. Call the algebraic difference of grades d, then will F B = L d, and since C D = ½ C E by the second property, M = ¼ F B, or

$$M = \tfrac{1}{4} L d. \qquad (2)$$

The length of curve, 2 L, may be fixed by the circumstances of the case or may be found by assuming a certain rate of change of grade per station, the rate of change increasing with d. Call this rate of change R, then for L in stations.

$$L = \frac{d}{2R}. \qquad (3)$$

To find the correction at a point one station distant from the P. C. at A, insert the value of d from (3) in (2), and the resulting value for M in (1), x being one station; the result is

$$T_1 = \tfrac{1}{2} \frac{L^2 R}{L^2} = \tfrac{1}{2} R. \qquad (4)$$

At two stations from A, $T_2 = 2R$; at three stations, $T_3 = 4\frac{1}{2} R$; at half a station, $T_{\frac{1}{2}} = \frac{1}{8} R$, etc.

The table gives values of T for points 50 ft. apart for a few values of L and d. These corrections must be added when the algebraic difference of grades is minus, and subtracted when the algebraic difference is plus. Similar tables for other lengths of curves or differences of grades may be prepared at the engineer's leisure, and time in the field may be saved by their use.

Yours truly, J. C. Nagle.

College Station, Tex., Oct. 10, 1896.

Table of Corrections for Vertical Curves.

Algebraic difference of grades.	Rate of change per station.	Distance from Vertex in Feet.								
d	Ft.	0	50	100	150	200	250	300	350	400
0.3	0.075	0.15	0.08	0.04	0.01	0	...	...	...	...
0.4	.1	.20	.11	.05	.01	0	...	...	...	...
0.5	.125	.25	.14	.06	.02	0	...	...	...	...
0.6	.15	.30	.17	.08	.02	0	...	...	...	...
0.7	.175	.35	.20	.09	.02	0	...	...	...	...
0.8	.20	.40	.23	.10	.03	0	...	...	...	...
0.9	.225	.45	.25	.11	.03	0	...	...	...	...
1.0	.25	.50	.28	.13	.03	0	...	...	...	...
1.1	0.1833	.83	.57	.37	.21	.09	0.2	0	...	..
1.2	.20	.90	.63	.40	.23	.10	0.3	0	...	...
1.3	.2167	.98	.68	.44	.24	.11	0.3	0	...	...
1.4	.2333	1.05	.73	.47	.26	.12	0.3	0	...	...
1.5	.25	1.13	.78	.50	.28	.13	0.3	0	...	...
1.6	.2667	1.20	.83	.53	.30	.13	0.3	0	...	...
1.7	.2833	1.28	.89	.57	.32	.14	0.4	0	...	...
1.8	.30	1.35	.94	.60	.34	.15	0.4	0	...	..
1.9	0.2375	1.90	1.46	1.07	.74	.48	.27	.12	.03	0
2.0	.25	2.00	1.53	1.13	.78	.50	.28	.13	.03	0
2.1	.2625	2.10	1.61	1.18	.82	.53	.30	.13	.03	0
2.2	.275	2.20	1.68	1.24	.86	.55	.31	.14	.03	0
2.3	.2875	2.30	1.76	1.29	.90	.58	.32	.14	.04	0
2.4	.3	2.40	1.84	1.35	.94	.60	.34	.15	.04	0
2.5	.3125	2.50	1.91	1.41	.97	.63	.35	.16	.04	0
2.6	.325	2.60	1.90	1.46	1.02	.65	.37	.16	.04	0

(The advantages of the use of vertical curves in relation to the operation of train service is discussed at some length in Wellington's "Economic Theory of Railway Location," and it is there pointed out that these advantages are of far greater importance at sags than at summits, the length for such curves being recommended as 200 ft. on each side of the vertex. It is also pointed out, however, that with the universal adoption of an automatic close coupler much of the importance of these vertical curves would disappear. With trains having much slack in the couplings a rate of change of grade of 0.025 per station of 100 ft. would best fill the required conditions, but for ordinary service (especially after the introduction of improved couplers) 0.05 per station will be ample. Wellington's book, however, gives only the vertical distance between vertex and curve, while the table given with our correspondent's letter gives the vertical distances at intermediate points. —Ed.)

NAVAL PRACTICE IN SHIP RIVETS AND RIVETING.*

By J. H. Linnard, Naval Constructor, U. S. N., Member.

Among the most important details of hull construction are the methods by which the different parts are attached to each other to give strength to the whole. Too much care cannot be taken to secure such arrangements as will provide strength combined with cheapness of execution. Too often in shipyards insufficient attention is given to this matter, and while general indications as to the riveting are usually put on plating plans, the details of spacing, etc., in important connections are frequently left to the judgment of foremen, or, indeed, the ironworker who lays out the work.

In merchant work, Lloyd's rules have been adopted as the general standard, but they fail to give information in several particulars. Thus the spacing of rivets in the angles uniting water-tight frames and bulkheads to the outer skin plating is not specified. No information is given as to what is considered a suitable size of rivet head, etc. In the hulls of the very large passenger steamers these matters have assumed great importance, and we hear of riveting proving defective and of rivets having to be cut out and replaced more frequently than in times past.

In men-of-war, where scantlings have been cut down to the lowest limit of safety, the detailed consideration of the riveting becomes of capital importance. In such work, where weight-saving without sacrifice of strength becomes so necessary, certain departures from merchant practice as exemplified in Lloyd's rules have been very general in the different navies. These relate principally to the breadth of laps and straps, connection of frames to outside plating, the shape of rivet heads, etc.

In our own Navy it has been the practice to follow in general the rules of the British Admiralty. Some years ago, in the course of the work in which I was then engaged, it became desirable to draw up rules for riveting for the guidance of draftsmen and foremen in considerably greater detail than any given in the Government specifications. At that time the available information on the subject was collated, the practice in different services compared, and the results embodied in a series of tables which have since been adopted, with some minor modifications, in a number of yards in which our new vessels have been building. It has been thought that these tables might be found of interest to the Society and might lead to a profitable discussion as to whether modifications in them are desirable.

In no particular of riveting work is greater diversity shown than in the shapes of the rivet heads. This is due to the fact that, in by far the greater part of riveted connections, the principal stress on the rivets is a shearing stress and the heads are usually more than ample to resist the forces exerted on them. Where it is necessary to study weight-saving, the size and shape of the rivet head becomes of considerable importance. In a vessel such as the armored cruiser "Brooklyn," the weight of rivets driven is upward of 330,000 lbs., and, of this weight, from one-fourth to one-third is in the rivet heads. Any method by which any considerable percentage of weight can be saved in the heads is therefore worthy of consideration.

The rivet head which has the least weight is the countersunk head, since practically all of the head is simply a replacement of metal taken from the plate. It has, however, the disadvantages of increased cost due to the labor of countersinking, and the decrease in the tensile strength of the plate or shape, owing to the greater section of metal removed from the hole. In the French service the saving of weight is considered of sufficient importance to counterbalance these disadvantages, so that the greater part of the riveting, except very light work, is executed with countersunk heads. In our own Navy, such heads are only used where the character of the work requires it on other grounds. It should be pointed out that where countersunk heads are used it is important that they

*A paper read at the fourth general meeting of the Society of Naval Architects and Marine Engineers, New York, Nov. 12, 1896.

should fit the countersunk holes in the plate. The angle at the apex should be a very little sharper, so that the head will be sure to bottom well. The blow of the hold up will then cause the head to completely fill the countersink.

In Fig. 1 are shown the dimensions of the different shapes of rivet heads adopted. The pan heads are those adopted by the British Admiralty. The tap rivet heads have squares on them of dimensions determined by experiment. They are the minimum necessary to set the rivet home strongly without wringing off the square with the wrench. It has been found by our own rivet makers that it is difficult to get these pan heads sufficiently well

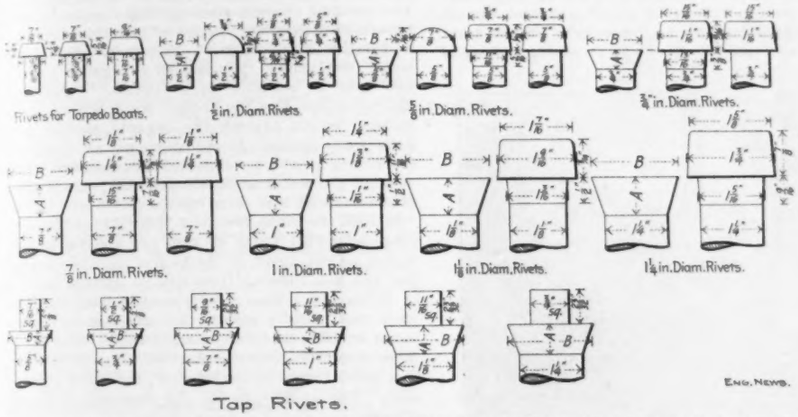


FIG. 1.—STANDARD RIVET HEADS IN USE BY THE BUREAU OF CONSTRUCTION AND REPAIR, U. S. NAVY.

(For all countersunk head and tap rivets make dimension A equal thickness of plate plus 1-16 in. Dimension B as per angle of countersink for given depth of head. Tap rivets will be ¼-in. larger than the corresponding rivets for the same thickness of plate; except those in stem and stern post, which will be ¼-in. larger.)

centered on the shanks of the rivets to meet the requirements of the inspectors.

The Bureau of Construction and Repair considers it of vital importance that these cone-head rivets should be true to figure. A slight eccentricity of the rivet holes is sometimes unavoidable, and if the closing rivet itself should also be eccentric, the lip would not cover as it ought, and therefore, whenever there is eccentricity apparent to the eye, the rivet must be rejected. Experienced rivet makers with the best appliances have found it practically impossible to make rivets with these heads absolutely concentric. The shortest diameter of the head is considerably greater than the diameter of the rivet blank. The result of the heading operation is that if there is the slightest crookedness in the blank, or if it is not sheared perfectly square, the head will be formed unavoidably on either one side or the other of the centre line of the rivet, because the rivet blank is free to wabble about, and is not held centrally as it should be by the heading die. A rivet head whose shortest diameter is exactly equal to that of the rivet avoids this difficulty, because if the rivet blank is bent, or in anywise eccentric or sheared obliquely, it will be caught by the header and straightened up and the head formed true and central in every instance. This is the form of cup largely used in making boiler rivets.

Years ago the Government adopted a standard for bolts and nuts, including form of threads, and this standard has been of great use not only to manufacturers of bolts, but to engineering establishments throughout the country, most of whom have adopted it. In a similar way, if the Navy Department were to establish a consistent standard for forms of rivets, it would also, no doubt, be adopted by other users of rivets throughout the country, with equal advantage.

A large manufacturer of rivets writes:

The proportions we adopted for our boiler rivet heads several years ago, and which have been used ever since with the greatest satisfaction, are as follows: The height of cone head is ⅞ the diameter of the rivet shank. The least diameter of cone head is equal to the diameter of the rivet shank. The greatest diameter of cone head and button head, 1⅜ times the diameter of the rivet shank. The height of the head of button-head rivet is equal to ¾ the diameter of the rivet shank.

This manufacturer suggested the adoption of these heads for hull-riveting also.

It will be observed that the rivet head proposed is considerably heavier than the Admiralty head. With the authority of the Bureau of Construction and Repair, a new type of rivet head has been adopted for the most recent vessels. They are substantially as follows: The diameter of head at top is equal to the diameter of rivet, at bottom is 1⅝ diameters; and the height is ¾ of the diameter of shank. These heads are substantially identical in weight with the Admiralty heads, except for the smaller sizes, which are from 5 to 10% heavier. The detailed dimensions of these heads are shown in Fig. 2. They have proved amply strong in use and are easily manufactured. It is possible that the height of the head could be still slightly reduced.

In sizes above ½ in., intended to be driven in punched holes, there is a taper enlargement under the head, the diameter just under the head being 1-16 in. greater than that of the rivet, and tapering down in about half a diameter. This taper under the head is better adapted to fill the hole made by the punch than the straight shank. It has been claimed by some that they are more troublesome to drive, but no difficulty has been found by those who have adopted them, and they unquestionably add materially to the strength of the riveting by better filling the rivet holes.

In table 8, 8 of Lloyd's rules is indicated the shape of countersunk points required for outside plating. This requirement cannot be practically carried out with exactness, for it requires a different angle of countersink for each size of rivet and each thickness of plating. After some experiments, it was found that the countersinks could be greatly simplified. The angles adopted are indicated in Fig. 2. The trapezoids shown give convenient dimensions from which templates can be made for keeping the countersunk tools true. It will be observed that the 45° countersink answers for three-quarters of all rivets driven in a ship-yard.

It is intended that the rivet holes should be countersunk through the plate to within 1-32 in. of the bottom of the hole in all cases. This has the advantage of removing most of the metal weakened by the punching.

This varying depth of countersunk holes leads to some slight inconvenience in ordering countersunk-head rivets, and it has been proposed to fix standard depths as follows:

Diam. rivet., ins.	½	⅝	¾	⅞	1	1¼
Depth countersink, ins.	5-32	7-32	11-32	½	⅝	⅝

The relation of the diameters of rivets to thickness of plates and shapes is regulated by a number of conditions. The rivet hole must not be too small to be punched through the plate. It must not be too large as to crush down the plate before shearing. It must not be so large as to require placing so far back from the edge as to prevent satisfactory caulking. For a given thickness of plate, the strongest joint is obtained by the largest permissible rivet. The rivets must not be too large for ready hand driving. Out of these conditions there has grown up a tolerably uniform practice for ship work in all countries. The introduction of steel plates and steel rivets caused an augmentation of the size of rivet relatively to the plate, owing to the relative weakness of steel rivets to steel plates as compared to iron rivets in iron plates. Table I. shows the sizes adopted.

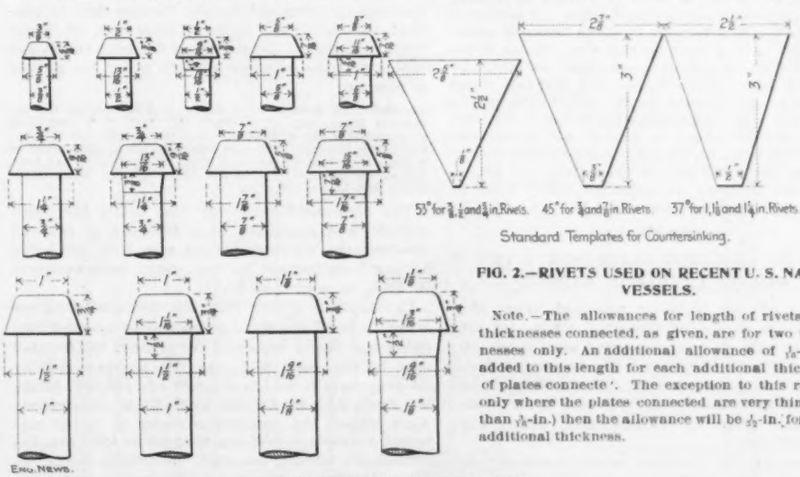

55° for ⅞, 1 and 1¼ in. Rivets.
45° for ¾ and ⅞ in. Rivets.
37° for 1, 1⅛ and 1¼ in. Rivets.
Standard Templates for Countersinking.
ENG. NEWS.

FIG. 2.—RIVETS USED ON RECENT U. S. NAVAL VESSELS.

Note.—The allowances for length of rivets over thicknesses connected, as given, are for two thicknesses only. An additional allowance of $\frac{1}{16}$-in. is added to this length for each additional thickness of plates connected. The exception to this rule is only where the plates connected are very thin (less than $\frac{1}{16}$-in.) then the allowance will be $\frac{1}{32}$-in. for each additional thickness.

Type of points.	DIAMETER OF RIVETS—INCHES.								
	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝
	ALLOWANCE FOR LENGTH OF RIVETS, OVER THICKNESSES CONNECTED—INCHES.								
Countersunk.	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
Mashed.	⅝	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½
Button.	⅝	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½

TABLE I.—Relation Between Diameter of Rivets and Rivet Holes and Weight of Plates.

Weight of Plates.	Diameter of corresponding rivets. ins.	Diameter of corresponding rivet holes. ins.
Up to 6 lbs. exclusive	⅜	7-16
6 " 8 " "	½	9-16
8 " 15 " "	⅝	11-16
15 " 20 " "	¾	13-16
20 " 30 " "	⅞	15-16
30 " 40 " "	1	1 1-16
40 " 61 " "	1⅛	1 7-32
61 lbs. and above	1¼	1 11-32

TABLE II.—Breadths of Laps and Straps for Riveting.

(Centers of rivets to be placed not less than 1⅝ times the diameter from the edges. In double and treble riveting, the distance from center to center of rows to be not less than 2¼ diameters in laps, and 2½ in straps.)

Breadth of laps for single riveting	3½ diameters.
Breadth of laps for double riveting	5½ "
Breadth of laps for treble riveting	7⅝ "
Breadth of edge strip for single riveting	7 "
Breadth of butt-strap for double riveting	11½ "
Breadth of butt-strap for treble riveting	16⅛ "

TABLE III.—Spacing for Rivets.

Connection.	Number of diameters from center to center.
Single-riveted laps and straps	3½ +
Double-riveted laps and straps 15 lbs. and over	4 —
Double-riveted laps and straps under 15 lbs.	4 +
Treble-riveted laps	4½ —
Treble-riveted straps with alternate rivets in third row omitted	4 —
Longitudinal seams of plating required to be water-tight	4½ —
Connections of transverse frames not water-tight to outside plating	8 +
Deck plating to beams, and in general where special strength is not required	8 —
Connections of floor-plates, brackets, lightened intercostals, etc., to clips and angles	7 —
Connections of vertical keel angles where not water-tight, of angles and other stiffeners to bulkheads, of boiler and engine bearings and foundations generally	6 —
Connections of inner-bottom plating to all non-water-tight frames and longitudinals	5 +
Connections of angles of water-tight frames and longitudinals to all plating, and in general where water-tightness is required between plates and shapes	5 —
Connections of armor-shelf angle to shelf and outside plating	4½ —
In special cases of intercostals, beam ends, etc., where strength is required in connections of limited extent, spacing to be as required by circumstances, except that rivets in the same line should never be spaced less than	3

Notes.—The sign + indicates that if the exact spacing cannot be used, take the nearest over. The sign — indicates that if the exact spacing cannot be used take the nearest under.

A reasonable discretion should be used in connection with the signs + and — of the table, and where the spacing as laid off comes quite close to the requirements, but with the wrong sign, it will generally be better to use it than to depart too widely from the exact spacing in the direction indicated by the sign.

In cases where a rivet connects different thicknesses of plating together, the size of the rivet indicated for the greater thickness is to be used, provided it is not more than ⅛-in. larger than the size of rivet required for the lesser thickness. But in no case is the rivet to be less in diameter than the thickness of the thickest plate. Tap rivets will be ¼-in. larger than the corresponding rivets for the same thickness, except those in stem and stern post, which will be ¼-in. larger.

Table II. gives laps and straps suitable for plating. The widths are cut down from the requirements of Lloyds' rules, resulting in a considerable saving of weight. It is believed they are sufficient with first-class workmanship:

Table III. shows the rivet spacing adopted. The endeavor has been made to make it sufficiently detailed to provide for the greater part of the cases arising in hull work.

Where strength is required in laps and butted connections of plating, with the spacing indicated, single riveting is suitable only for plating under 12½ lbs., and double riveting under 25 lbs. Where strength is required in connections above 30 lbs., a special calculation should be made, and generally quadruple riveting will be required.

The tables of spacing have been slightly modified from those originally determined upon in the direction of closer spacing, which has seemed desirable, in view of the comparative weakness of the steel rivets used in the Navy.

In the French Navy a very elaborate series of rules for spacing of rivets in butts, laps, etc., has been adopted. These include the general use of staggered riveting, usually an irregular spacing of rivets in different rows, and, in special cases, the use of different sizes in the same joint. Some additional strength is doubtless thus obtained in the connections, but it does not appear worth the increased cost. The simpler methods of chain riveting have always been adopted by the British Admiralty and in our own service.

It has been mentioned above that on account of the comparative weakness of the steel rivets used in the Navy, it has seemed desirable to decrease the spacing. The requirements for rivet steel for the first steel cruisers were a minimum tensile strength of 60,000 lbs. per sq. in., and an elongation in 8 ins. of not less than 23%, with a shearing strength of not less than 50,000 lbs. per sq. in. The actual average results obtained from the tests were 64,740 lbs. per sq. in., and 27.41% elongation, with an average shearing strength of 53,695 lbs. per sq. in.*

The requirements for the recent ships have been between 55,000 and 62,000 lbs. tensile, with a minimum elongation of 20% in 8 ins., and a minimum shearing strength of 45,000 lbs. per sq. in. I am not informed as to the average results actually obtained, but with the limits between which the tensile strength is required to be maintained, the average shearing strength cannot exceed about 50,000 lbs. It seems very desirable to make a return towards the earlier specifications and sacrifice a little of the ductility in order to obtain increased shearing strength. A rivet steel for hull work, similar to the requirements of the present specifications for rivets for longitudinal boiler seams, appears very desirable. These requirements are between 58,000 and 67,000 tensile strength, with a maximum elongation of 26% in 8 inches. The maximum allowances of sulphur and phosphorus, which for hull rivets are .04 and .05* respectively, are for these boiler rivets .035 and .04 respectively, and with a metal of this character no difficulties should occur in the satisfactory driving of the rivets.

*Report of the Naval Advisory Board on "Mild Steel, etc.," prepared by Assistant Naval Constructor R. Gatewood, U. S. N., Washington, Government Printing Office, 1886.

REMOVAL OF IRON FROM WATER FROM A FILTER GALLERY AT READING, MASS.

Sulphate of iron is being removed from the ground water supply of Reading, Mass., by the addition of milk of lime, combined with thorough aeration and rapid filtration, the treatment proceeding in the order named. This process was adopted by the water commissioners after some two or three years of investigation, which will first be outlined.

Water-works for Reading were completed in 1891, with the late M. M. Tidd, M. Am. Soc. C. E., as engineer. Water is pumped from a filter gallery near the Ipswich River to a covered standpipe, 30 ft. in diameter and 100 ft. high. It was first proposed to put in driven wells, but after more extended investigation Mr. Tidd recommended a filter gallery at about the same locality, and this recommendation was followed. The estimated cost of the driven wells was $5,931, and of the filter gallery, $9,000. When bids were received for the work the water commissioners found it would cost $16,000; but the bidder who named that price, Mr. J. H. Leavitt, of Boston, also offered to do the work at a stated price per day. The latter proposition was accepted and the work was done at a cost of $16,562.

The bottom of the gallery is 22 ft. below the level of the meadow. The gallery is 3½ ft. wide and 4 ft. high, inside, L-shaped, with a total length of 250 ft. The walls are of rough field stone, like "an ordinary culvert under a street," and the gallery is covered with flat stone laid in cement. A 14-in. passage, controlled by a gate, connects one end of the gallery with a circular brick well 6 ft. in diameter, covered by a house of the same size and material. A 12-in. suction pipe, 450 ft. long, leads to the pumps. Another pump well and suction main makes possible an emergency supply from the Ipswich River. About 75 ft. of the gallery is

Fig. 1.—View of Pump and Filter House; Reading, Mass.

parallel with and about 40 ft. from the river; the remaining 175 ft. extends away from the river at a right angle.

It appears that the quantity of water obtained from the filter gallery has been satisfactory, but not so the quality. The studies which have been made of the quality of the water have been very interesting.

The Massachusetts State Board of Health had recommended a "supply from the ground near the Ipswich River," in 1889, before construction was started*. In its report for 1890 it says nothing regarding the proposed supply, further than to present two analyses, without comment, of water from a test well. In its report for 1891 the Board states that the meadow beneath which the gallery is located

> is subject to flowage to a depth of 5 ft. during the six months from Oct. 12 to April 12, * * * * and it is probable that the quality of the water is effected to some extent by the fact that the meadow has always acted to a greater or less extent as a filter every time it has been flowed on account of the difference in the water level above and below the dam.

The dam mentioned was just below the filter gallery, and has since been removed to prevent flooding, the water right and a mill at this point having been bought by the water commissioners in 1895, at a cost of $2,544.

In this same report, 1891, the chemical analyses of water from the filter gallery show marked turbidity and heavy sediment throughout the greater part of the year, although the average residue on evaporation was only 12.96 per 100,000, ranging from 9.35 in August to 26.40 in November. As a whole, the monthly samples of water collected during the last ten months of 1891 are described as having an odor "generally disagreeable, sometimes offensive." Regarding this odor and the iron in the water it is stated that:

> The water contains iron in solution, which precipitates out as a reddish-brown deposit on exposure to the air. Waters of this character often have a disagreeable odor from carburetted or sulphuretted hydrogen. * * * Sample No. 8,255 (the one with high residue on evaporation.—Ed.) is exceptional in this series, containing much more mineral and organic matter than the other samples. The amount of metallic iron in this sample was 1.33 parts per 100,000, or 0.78 grains per gallon. The colors given in the table are doubtless all due to the separation of iron oxide. The water as it comes from the ground is colorless.

No determinations for iron are given except the one cited. The color was zero in April, May and the first part of July, and during the balance of the year ranged from 0.02 in December to 0.40 in August, averaging 0.13, and being only 0.04 in November, the month of heavy sediment.

In 1892, the color was higher, averaging 0.42, and ranging from 0.00 in January to 0.80 in December. Iron determinations were reported for the last four months of the year, averaging 0.225 parts per 100,000. Crenothrix, a species of fungus, were present in large quantities during the greater part of this year, as were also zo-ogloea, an organism classed neither as plant or animal, but as miscellaneous, "owing to the uncertainty which attaches to the precise nature of the substance." The peculiar characteristic of these micro-organisms is that they are massed or bound together by a gelatinous envelope. Crenothrix thrives in water containing "decomposing organic matter and iron in solution as protoxide."** Partially filtered water, like the ground water from a filter gallery, would furnish the organic matter, and with iron present in addition as at Reading, crenothrix might be expected in profusion. The color of the water at Reading in 1892 was attributed to "crenothrix or zo-ogloea and iron."

In 1893 the State Board of Health found an average of 0.1251 parts of iron per 100,000 in the water, as the result of the twelve monthly analyses, the iron ranging from 0.01 in August to 0.54 in November. The color averaged 0.64, and the odor was "faintly moldy or unpleasant, often none; in June and July disagreeable." The sediment was often heavy and rusty. Organic matter, in a partial state of nitrification, was quite prominent. The comments on the analyses were as follows:

> The water offers a good instance of the effect of a marshy soil on the character of the water percolating through it. The organic matter of the soil consumes the free dissolved oxygen in the water and reduces the insoluble iron salts to the condition of protoxide, so that iron passes into solution in the water. On exposure of the water to the air the iron is again oxidized, forming first a precipitate which gives the water a milky appearance and ultimately settles as a rusty sediment. Conditions in some respects similar to those of Reading are found in Provincetown, Bradford and Watertown, and were found in the test wells at Attleborough (see 23d Annual Report, 1891).
>
> The determinations of turbidity and color in waters of this kind do not have the same significance as in surface waters, but they are, nevertheless, of interest as showing a condition which the water may assume, and are therefore given in the table.

The first three reports of the Reading Water Commissioners, two of which were published after the works were put in operation, contain no reference to the quality of the water, but evidently it occasioned anxiety as early as the latter part of 1892, at least, for in the report for 1893 it is stated that in February of that year Mr. Desmond FitzGerald, M. Am. Soc. C. E., was engaged

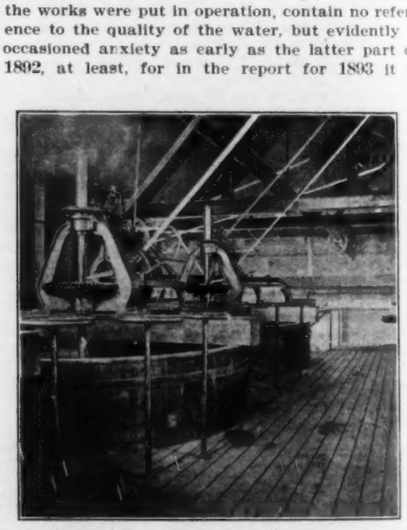


Fig. 4.—View of Top of Warren Filters; Reading, Mass.

> to make a careful examination of our source of supply, to ascertain, if possible, the cause of the disagreeable odor and color of the water and to advise us what steps to take to remedy the existing troubles. He was also requested to advise us in regard to other sources of supply, both within and without the boundaries of the town.

Mr. FitzGerald continued his studies for a year, not reporting until February, 1894 (the report appears, however, in the annual report for

**It must not be inferred that this recommendation related to the mode adopted years later to develop water, but only to the general source.

*Examination of Water Supplies. Special Report Mass State Board of Health, 1890, p. 781.

1886). After preliminary remarks the report discusses the situation as follows:

I first began to investigate the quality of the water as delivered to the consumer, and have found some curious phenomena. On the same street and in houses supplied from the same main, the quality of the water seemed to vary. At one house the water contained so much iron and had such an offensive odor that there was much just complaint. At the very next house there was no cause for complaint, the water appearing to be free from objection and used freely for drinking, for use in the teakettle and for the laundry. I soon found that the cause for this peculiar condition of things was due to the fact that where a service pipe had been in use long enough to lose its coating, the carbonic acid in the water acted with rapid effect upon the pipe.

The Reading water was already known to contain a considerable amount of iron; but after I became intimately acquainted with its peculiar and varied properties, I learned to have a wholesome respect for it. At one house I found that they could either draw good or bad water from the same main.* After some thought upon this condition of things, I advised your board to use nothing but cement-lined services until the quality of the water should be improved.

As might be expected, a certain amount of crenothorix is almost always present in the Reading water, and I first expected to find that this was one of the causes of complaint; but I found that this was not the case. Crenothrix is hardly abundant enough unless it is stirred up in the gallery or in other portions of the work. Samples from the manholes in the filter gallery can be taken in almost any variety of condition, according to the method of selecting the samples.

In the distribution system there is generally an almost entire absence of oxygen in the water; but there is no lack of offensive gases of one kind or another to annoy the water taker. If the lack of oxygen was the sole trouble, the remedy would be a simple one. More aeration would only have the effect to drive off the obnoxious gases and change the form of the iron from the ferrous to the ferric condition; in other words, to deepen the color of the water and hasten precipitation of the iron. It soon became evident that the Reading water was no ordinary liquid. A great many experiments were made, both by myself, and under the direction of Thomas M. Drown, M. D., of the Massachusetts Institute of Technology, to whom I am much indebted for long and patient advice upon the chemical side of the subject. Assistant F. L. Hollis made many able investigations and analyses to ascertain the effect of the gases and acids in the water. A great many determinations were also made of the amount of iron in the water, and I left no stone unturned to ascertain the condition of the water in the different portions of the system at different times of the year.

I found that generally one-half of the water came from the river directly down into the gallery by very rapid and imperfect filtration, and that the other half came from the ground. A careful examination of the materials in the ground between the filter gallery and the high land by means of driven wells, some of them put down especially for this investigation, showed that there was not enough water for the supply of the town from the ground alone. An extension of the driven wells up the valley of the Ipswich River gave no better results. The material underlying the meadows is of too fine a quality for a successful application of the artesian or driven well system.

Having found after due consideration that there was no easy way to make the Reading water acceptable, or to procure an additional supply in the immediate neighborhood of the works, I next turned my attention to other sources of supply.

The further I went into the study of the question of other sources, the more convinced I became that it would be a very expensive matter for Reading to abandon its present supply, so I applied myself diligently to the question of purification of the present water. After much study and thought and the consideration of many plans, I finally recommended to your Board the following outline of works for purifying the Reading water which, to the best of my belief, will render the quality of your water perfectly satisfactory to the citizens of Reading:

1. Pump the water from the filter gallery into a covered reservoir built in two sections, each of which should hold 500,000 gallons.

2. Aerate the water thoroughly on its way to this reservoir.

3. Build invert to the reservoir with a steep inclination towards the drains, so that the sediment precipitated upon the bottom will scour easily.

4. Place this reservoir high enough to filter the water and return it to its present pumps. The water drawn from this reservoir can be filtered rapidly through any cheap form of filter which can be readily cleaned.

5. After the plans are made, I should recommend you to put in the filters at once, and run them without the reservoir until the opening of the coming season.

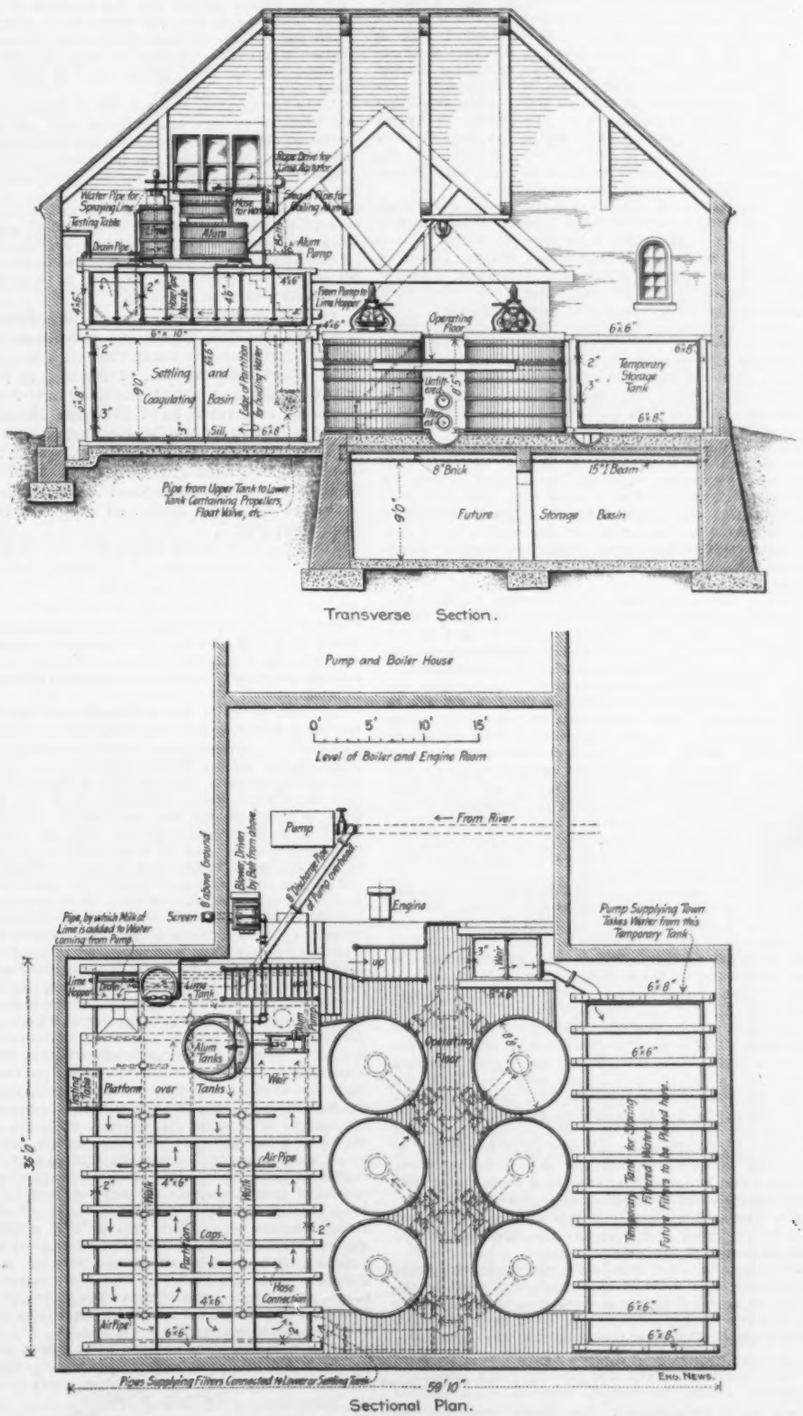
6. The outlets or drains to the reservoir should be so arranged that the flocculent iron can be collected for use, if found necessary. I have found in my experiments, and it was suggested by Dr. Drown, that by adding some of this flocculent iron to the water, the precipitation of the iron is somewhat hastened.

*The explanation of this, Mr. FitzGerald states in a letter to this journal, is that there were two service pipes of different material in the same house.—Ed.

The water commissioners stated in their report for 1893 that Mr. F. L. Fuller, M. Am. Soc. C. E., was then preparing plans for the settling tanks, filters and reservoirs necessary to carry out Mr. FitzGerald's recommendations, and that the work was to be done at once. For some reason it was concluded to investigate the matter still further before beginning work. In March, 1894, the State Board of Health was asked for advice regarding the proposed purification scheme, and also whether it would recommend the securing of water from a new source. Other sources were investigated, but none were approved, the Board recommending that Reading take steps to secure a permanent supply from the new works then proposed and now under construction for the metropolitan district of Boston, and concluding:

In the meantime, provision should be made to improve the present supply by preventing the flooding of the meadow over the filter gallery, and it may be advisable to adopt temporarily, some system for filtering the water rapidly through sand.

The report of the State Board of Health was not made until February, 1895, owing to the desire



FIGS. 2 AND 3.—PLAN AND SECTION OF WATER PURIFICATION PLANT; READING, MASS.
Cumberland Manufacturing Co., Boston, Mass., Contractors.

to study the problem during the fall and winter of 1894-5, when the meadows above the filter gallery were flooded. The portion of the report relating to the studies of water from the filter gallery is as follows:

A very large number of examinations of the water of the filter-gallery have been made during these investigations and previously, and from these results it appears that the objectionable character of the Reading water is due chiefly to the presence at nearly all times of an excessive amount of iron in connection with other mineral and organic matter. The amount of iron found in the water varies greatly at different times, being very large in the portion of the year when the meadow is covered with water and much smaller during the summer when the meadow is dry. It has also been observed that the quantity of iron present in the water may vary greatly in the course of a single day's pumping.

In contrast with other waters in which a sufficient amount of iron has been found to effect the appearance and quality of the water, it has been found that the iron in the Reading water is present as a sulphate instead of being in the form of a bicarbonate. When iron is present as a sulphate its removal from water is very much more difficult than when it is present as a bicarbonate.

Many experiments have been made at different times with a view to a removal of the iron by oxidation and subsequent filtration of the water through sand to remove the precipitated iron oxide. The results obtained by this means have been very variable. But, in general, it may be said that when the iron is present in the water in small amount, say not over 0.3 of a part per 100,000, the iron will separate out of the water almost completely on exposure to the air for 24 to 36 hours in the form of a rusty precipitate, which can be removed entirely by filtration through sand at a rapid rate. This method is substantially that proposed by Mr. Desmond FitzGerald in his report to your Board. Forced aeration by filtering through sand with a current of air was found in almost all cases to hasten the oxidation and separation of the iron oxide.

But in one case, at least, when the iron was only 0.14 parts per 100,000, aeration in this way had but little effect on the iron. The failure to remove the iron in this case seemed to be connected with a considerable amount of organic matter in the water which prevented the precipitation of the iron after oxidation.

Again, the difficulty in removing the iron appears to increase rapidly with the amount of iron in the water, and when large amounts are present, say from one to two parts per 100,000, which has been frequently the case the past winter, the means found adequate to remove the iron when present in small amounts are unavailing. Exposure to the air for two days had practically no effect on the iron contents of the water of this character, and even after thorough aeration, it separated out only in part, leaving most of the iron still in the water, upon which filtration had no effect.

During the progress of this investigation, advantage has been taken of the presence at the Reading pumping station of a small mechanical filter placed there and first operated about the middle of the summer. This filter consisted of two upright cylinders, one said to contain 30 ins. in depth of sand, and the other 30 ins. of bone-char, each having an area of about 1 sq. ft. Later in the season the number of cylinders was doubled.

Experiments with this filter showed that with iron not exceeding 0.1 of a part per 100,000, rapid filtration alone without exposure to the air was capable of removing practically all of the iron in the water, but when the water contained large amounts of iron, the action of the filter was uncertain. With very high iron, say one part per 100,000, the filter had no effect whatever on the amount of iron. No special advantage was found in the use of bone-char in these experiments, and it is, therefore, probable that any sand filter capable of being readily and thoroughly cleaned would do equally good work.

Any treatment by filtration which will remove the iron will be very likely also to remove the objectionable odor and appearance of the water.

When the amount of iron in the water was very high, experiments were made to learn whether it could be removed by chemical means, a cheap form of which would be filtration through carbonate of lime, in the form of marble chips. The experiments in this line have indicated that the iron can be completely removed by filtration through carbonate of lime, but that in this process the water takes up lime in large amount and is made very hard. A combined process of aeration and filtration through sand and with subsequent filtration through carbonate of lime, leaves the water much less hard than when it is put directly on to a filter containing marble, and the results indicate that the hardness of the water after treatment in this way would be at least 16 to 18 parts per 100,000, while the hardness of the water after filtration through carbonate of lime, without previous aeration and filtration through sand, is likely to be at least 25 parts per 100,000.

While the hardness of the water, if treated chemically, by filtration through carbonate of lime as suggested, would be very little or no greater than that of waters supplied to some of the towns in the vicinity of Boston, the board does not recommend the use of so hard a water for a permanent supply.

Since the higher amounts of iron and organic matter are found when the meadow is flooded, it would seem that the quality of water in these respects might be greatly improved and the water rendered more susceptible of further improvement by filtration or other treatment if this flooding were prevented.

In 1895 the water commissioners purchased and removed the dam which had caused the flooding of the meadows and contracted with the Cumberland Manufacturing Co., of Boston, to put in a purification plant, which combined lime treatment, aeration and rapid sand filtration through mechanical filters of the Warren type. Mr. Walter B. Nye, Manager of the company, states that his company had been studying the water for three years. The purification plant is located in an addition to the pump house, as shown in the general view, Fig. 1.

The character of the plant can best be set forth by using a description of it kindly sent us by Mr. Nye, under date of Sept. 14, 1896, as follows:

Stated briefly, we proposed to add lime to the water, aerate it, and if necessary to still further coagulate the oxidized iron in suspension in case it did not coagulate sufficiently of itself, to render it removable by mechanical filtration.

The plant, shown in plan and section by Figs. 2 and 3, consists of a settling and coagulating basin, approximately $33 \times 19 \times 9$ ft., above which is placed an aerating basin, $33 \times 19 \times 4\frac{1}{2}$ ft., and six Warren filters, 8⅔ ft. in diameter and 8 ft. 5 ins. deep, together with a temporary storage tank for filtered water, approximately $31 \times 10\frac{1}{2} \times 8$ ft., from which the pumps take their supply. The water is taken from the existing suction main by a low duty Worthington pump, and by it delivered to the aerating basin. The water is delivered through a hopper at one end of this basin, and as it rises in the same meets the descending supply of milk of lime, which is prepared by the automatic slaking device used in our Keyport plant (Eng. News, June 4, 1896). On receiving the lime it passes into the aerating basin proper, which is so divided by partitions as to cause the water to travel back and forth four times before passing over the final weir and entering the settling basin below. The water, during this passage, receives violent aeration by means of 23 1¼-in. nozzles, perforated with 15 1-32-in. holes. Air for this aeration is supplied by a No. ½ Wilbraham Baker blower, which has a guaranteed capacity of 150 cu. ft. of air per min., at a maximum pressure of 3 lbs. The actual pressure due to the friction of the pipe, aerating nozzles, and the depth of the column of water at the outlet is about 2½ lbs., as shown by a mercury gage. By this method, each particle of water receives 23 successive aerations, thus thoroughly oxidizing the iron, and the water together with the suspended iron passes over the last weir and through a 10-in. pipe, at the outlet of which is one of our standard alum propellers (Eng. News, Jan. 4, 1894) whereby the water is supplied with the amount of dilute alum solution necessary for its coagulation. In this basin the water remains for about one hour, and from there passes to the filters, which are of standard type. The upper portions of two of the filters, with the mechanism for driving the sand agitators are shown by the view, Fig. 4. The filtered water, now bright, clear and sparkling, passes over the weir shown in Fig. 1, and from this is taken to a temporary storage tank, which occupies the place prepared for the addition to the filter plant.

As shown on the section, Fig. 2, a storage tank for filtered water is provided underneath the filters, but owing to the necessity of constructing it in winter it was found difficult to secure a tight wall and the temporary wooden tank was constructed for use during the present season.

Owing to the changeable character of the water a strict watch is kept upon it and every hour the incoming water is tested for iron, and the water both before and after aeration and after coagulation is tested both for alkalinity and iron. For the taking of these tests we have prepared a sufficient supply of standard indicator, together with the necessary simple apparatus, and the engineer in charge has no difficulty in making his tests and in so regulating the amount of lime and of alum as to prevent the use of an excess and enable the plant to properly handle the water.

We use in this case our 8⅔-ft. filter instead of the larger size, for the reason that its use seemed to allow a better arrangement of the plant, both for the present and future, in view of the size of basin necessary, and the fact that the land and the development of the plant were limited by water on two sides.

We enclose copies (Table I.) from the State Board of Health reports both for July and August (September and October sent since.—Ed.) and also our own analyses, recently made.* At the time the July and August samples were taken, the plant was being worked to its fullest capacity, pumping about 14 hours a day, which with the small force employed prevented giving the plant as close chemical attention as they desired and in consequence the hardness is a little greater than expected. At the present time (Sept. 14, 1896) they are pumping 7½ hours a day; the average pumpage is 247,486 gallons; the average alum consumed is 36 lbs., and the average lime, 70 lbs.

As the engineer in charge becomes better acquainted with the plant and with the methods, it is probable that the consumption can be materially decreased, as in this particular instance the skill of the operator would have much to do with the economy of the operation.

On starting the plant, we met with some difficulty, owing to the character of the lime, and it was only after considerable experiment that we found that a perfectly pure lime made from marble was much better adapted to this purpose than the ordinary lime of commerce, and a supply is now secured from northern Vermont which meets the requirements in every particular. The necessity for coagulation is due to the fact that the iron varies greatly in its behavior under treatment by lime and aeration. At times the hydrate of iron forms in sufficiently large flakes to serve as its own coagulum; at other times the oxidized iron is in so minute a form as to render the water brown like beer, under which conditions it will pass through any form of filtering medium, unless a coagulant is used. Without a coagulant water can be secured which will be perfectly clear and apparently white, except in large volume, where it might show a slightly greenish tinge, but by using a coagulant this is removed and the water is perfectly limpid and clear. The citizens are thoroughly pleased, the water seems to be useful in more commerical ways than it was before, and apparently the only evil to result from the installation of the apparatus is the great increase in the consumption of water, which has taxed both men and facilities ever since the plant was put in.

In a more recent letter (Oct. 31), Mr. Nye writes as follows:

In the analyses recently sent you I would call your attention to two of them in particular, one showing about 83% removal of iron and one showing 100%. The difference in total hardness and total solids, as you will note, bears a very close relation to the removal of iron and reduction in ammonias, and the two samples show, first, the result of insufficient lime, and, second, the result of too much lime. During the warm weather the character of the water varied greatly and the consumption was large, and as a result the operators did not always catch the changes in the water sufficiently early, but at no time has there been any hardness which was appreciable to the community, and there has been nothing but complete satisfaction.

With the letter from which the above was taken

*The analyses sent by Mr. Nye were only partial. They showed a reduction of iron from 0.356 to 0.020 or 94%. —Ed.

TABLE I.—Anayises of Unfiltered and Filtered Water from Reading, Mass., Made by the Massachusetts State Board of Health.
(Parts in 100,000.)

Date of collection. 1896.	Appearance. Turbidity.	Sediment.	Color.	Odor. Cold.	Odor. Hot.	Residue on evpration.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen consumed.	Hardness.*	Iron.	P. c. of rem. of iron.	Remarks.
July 27	Decided.	Cons. rusty.	[1]0.40	Faintly vegetable.	Faintly vegtble.	9.50	.0048	.0076	.53	.0050	.0000	.3420	3.6	.0850	.....	Unfiltered.
" 27	None.	None.	0.13	None.	None.	15.50	.0058	.0056	.52	.0030	.0000	.1520	8.2	.0090	89.41	Filtered.
Aug. 10	Decided.	Considerable	0.63	Faintly mouldy.	Faintly mouldy.	8.70	.0048	.0056	.54	.0000	.0001	.3635	2.6	.1400	.....	Unfiltered.
" 10	Very slight.	None.	0.30	None.	Faintly mouldy.	14.50	.0040	.0046	....	.0000	.0002	.2410	7.9	.0210	85.00	Filtered.
" 25	Decided.	Considerable	0.60	Faintly vegetable.	Dist. vegetable.	7.40	.0070	.0064	.56	.0000	.0000	.3542	2.5	.0950	.....	Unfiltered.
" 25	None.	Very slight.	0.20	None.	Distinct.	14.20	.0044	.0056	.52	.0020	.0010	.2010	8.0	.0030	96.84	Filtered.
Sept. 8	Dist. from iron.	Cons. brown.	0.50	Faintly vegetable.	Faintly vegtble.	8.50	.0066	.0046	.62	.0030	.0030	.1725	2.6	.0950	.....	Unfiltered.
" 8	None.	Very slight.	0.20	None.	None.	13.90	.0030	.0044	.61	.0030	.0018	.1725	7.3	.0160	83.16	Filtered.
" 21	Decided from iron.	Heavy rusty.	0.38	None.	Faintly vegtble.	12.20	.0084	.0088	.56	.0050	.0000	.3160	3.9	.3350	.....	Unfiltered.
" 21	None.	None.	0.10	None.	Dist. unpisant.	18.00	.0048	.0062	.55	.0040	.0025	.2291	10.0	.0000	100.00	Filtered.
Oct. 6	Decided from iron.	Cons. rusty.	1.10	Faintly vegetable.	Dist. vegetable.	12.20	.0090	.0120	.56	.0030	.0001	.4068	4.0	.3800	.....	Unfiltered.
" 6	Very slight.	None.	0.09	None.	Faintly vegtble.	20.40	.0010	.0086	.57	.0030	.0035	.2923	11.3	.0100	97.37	Filtered.

*In terms of an equivalent amount of carbonate of lime in parts per 100,000. [1]Turbid.

Mr. Nye sent a copy of some analyses made for the Cumberland Manufacturing Co. by Prof. Henry Carmichael. These analyses are presented in Table II., the analyses made by the State Board of Health being given in Table I.

The total cost of the Reading purification plant has been about $19,000, divided as follows:

Building and clear water basin	$11,000
Suction pipe	1,436
Pumps, engines and connections	1,900
Settling basin, aerators and filter, about	7,000
Total	$21,336

As stated above, $2,544 was paid in 1895 for water rights and a mill in order that a dam might be torn down to prevent the flooding of the meadow over the filter gallery. In addition, $514 was expended for a dike in 1895. These items, however, should be added to the $16,562 paid for the filter gallery, making $19,630 as the cost of developing the supply.

The total pumpage in 1895 was 72,375,448 gallons, or an average of 198,289 per day. The total estimated population of Reading in 1895 was 4,717, of which it was estimated that 4,140 were on the lines of the distributing pipe, and 3,550 actually supplied. On the above basis the pumpage per inhabitant would average 42, and per consumer, 56 gallons per day.

Mr. Lewis M. Bancroft is superintendent of the Reading water-works, formerly one of the water commissioners, and has had charge of the construction of the works since their beginning. The water commissioners are now as follows: Messrs. Edward C. Nichols, Geo. E. Abbott and Calvin E. Martin.

TABLE II.—Analyses of Unfiltered and Filtered Water from Reading, Mass., made by Prof. Henry Carmichael (Samples Collected Sept. 26, 1896).
(Parts per 100,000.)

	Before filtration.	After filtration.
Total residue on evaporation	12.3000	19.1000
Organic and volatile matter	3.1000	4.6000
Chlorine	0.2655	0.2655
Free ammonia	0.0066	0.0020
Albuminoid ammonia	0.0090	0.0050
Iron as iron oxide	0.1070	0.0107
Hardness Clark's scale*	2.64°	4.51°

*Or, to make these comparable with the State Board of Health, analyses, by giving an equivalent amount of carbonate of lime in parts per 100,000, 3.80 before, and 6.40 after filtration.—Ed.

AN INLAND HARBOR AT THE SOUTH END OF Lake Michigan and just southeast of Chicago, Ill., is proposed in a measure to be presented, it is stated, at the coming session of the Indiana State Legislature. The measure authorizes North Township, Indiana, to issue bonds to the amount of $200,000, for the purpose of constructing a waterway between Lake Michigan and the Grand Calumet River, at a point one mile east of Hammond, Ind. It is stated that plans for the project, which involves the building of inland harbors in Wolf and George Lakes, have been drawn in accordance with Major W. L. Marshall's views, and submitted to him for approval. They show a canal 300 ft. wide from Wolf River, where it enters Lake Michigan, to the Calumet River. Entrance will be made at Wolf Lake, where a basin 600 ft. wide and 7,500 ft. long will be dredged, the canal continuing in a direct line to George Lake, where a basin 450 ft. wide and a mile long will be built. Leaving the lakes, there will be a canal 300 ft. wide and 20 ft. deep, through sections 19, 30 and 31. The committee having charge of the movement is composed of Edward Roby, C. A. Shedd, C. F. Mott, General Charles F. Griffin, A. F. Knotts, Marcus M. Towle, Senator William H. Goslin and others. Congress has appropriated $80,000 for the Wolf Lake Harbor, and if the Indiana Legislature approves the project, it is stated that it will be begun early next spring. The place seems to be one of several which have been the outcome of the inadequate harbor facilities of the Chicago River, which were discussed at some length in Engineering News of July 16, 1896.

A CHARLESTON-LIVERPOOL STEAMSHIP LINE, the Johnson Blue Cross Line, is to commence operations in December under the management of the Charleston Shipping Co. It is the first step in a proposed development of direct trade between Europe and Charleston, S. C.

A $3,000,000 FILTRATION ORDINANCE has passed the Philadelphia Common Council by a vote of 99 to 3. The ordinance authorizes a loan of the above amount "for the purpose of constructing and erecting a filtration plant or plants, to connect with the several pumping stations embraced in the water supply of the city of Philadelphia." The ordinance must still pass the Select Council.

WEATHER TABLE FOR OCTOBER, 1896. (Furnished to Engineering News by the Department of Agriculture.)

	Stations.	Temperature. (Degrees Fahrenheit.) Average.	Max.	Min.	Range.	Wind. Velocity in miles per hour. Average.	Max.	Direction at time of max. velocity.	Precipitation—rain or melted snow—inches. Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	42.5	64	20	44	7.4	34	SE	2.42	0.79	16
	Portland, Me.	46.1	70	30	40	7.8	34	S	3.19	1.46	15
	New York City	51.9	72	36	36	14.2	45	NW	1.71	0.76	11
	Pittsburg, Pa.	50.6	79	30	49	5.5	23	SW	2.26	1.03	13
	Chicago, Ill.	49.6	75	29	46	16.5	62	S	1.36	0.92	6
	Omaha, Neb.	51.5	82	26	56	7.2	24	N	3.72	1.83	10
	St. Paul, Minn.	45.5	75	21	54	6.8	26	SE	3.39	1.74	9
	Duluth, Minn.	41.8	75	19	56	10.4	55	NE	3.46	1.16	11
	Bismarck, N. Dak.	42.0	77	13	64	8.2	37	NW	0.48	0.31	5
	Average	46.8	74	25	50	9.3	38		2.44	1.11	11
Southern Cities.	Washington, D. C.	54.0	76	31	45	6.7	28	NW	0.34	0.16	7
	Louisville, Ky.	56.3	82	32	50	6.5	31	SW	1.61	1.03	7
	St. Louis, Mo.	57.2	80	36	44	10.3	46	SW	1.20	0.40	8
	Savannah, Ga.	67.4	86	47	39	8.0	27	N	0.99	0.49	7
	Kansas City, Mo.	54.9	86	31	55	7.8	31	SW	2.99	1.59	6
	Jacksonville, Fla.	70.4	87	50	37	6.6	26	NE	3.03	1.45	8
	Chattanooga, Tenn.	60.3	81	35	46	6.3	40	S	1.06	0.60	3
	New Orleans, La.	70.4	91	54	37	7.8	54	N	5.33	2.66	9
	Memphis, Tenn.	62.0	85	40	45	8.2	36	SW	1.49	0.66	5
	Palestine, Tex.	66.4	92	45	47	4.8	22	SE	7.16	2.73	11
	Average	61.9	85	40	44	7.3	34		2.52	1.18	7
Western Cities.	Helena, Mont.	47.9	75	30	45	6.2	25	NW	0.24	0.18	3
	Port Angeles, Wash.	48.0	66	34	32	4.4	24	W	2.13	0.78	10
	San Francisco, Cal.	58.8	85	47	38	9.6	35	SE	1.55	1.16	5
	Salt Lake City, Utah.	54.4	82	33	49	5.7	34	NW	0.70	0.32	4
	Santa Fe, N. Mex.	48.5	70	30	40	5.6	27	NE	3.19	1.01	13
	Denver, Colo.	50.1	82	25	57	6.7	32	NW	0.84	0.42	5
	Yuma, Ariz.	75.5	102	48	54	4.4	24	SW	0.10	0.07	3
	Average	54.7	80	35	45	6.1	29		1.25	0.61	6

A WATER POWER AND ELECTRIC POWER PLANT is being built in Calaveras county, Cal., by the California Exploration Co., the power to be used for mining purposes. The head is about 1,043 ft.

THE UTILIZATION OF WATER POWER of the flow through the Tequixquiac drainage tunnel for the city of Mexico is being arranged for by the Electric & Irrigation Co., which proposes to put in a water wheel plant for driving dynamos to generate current which can be used for lighting and power purposes. Mr. Thomas W. Orbison is the Chief Engineer.

A WATER POWER AND ELECTRIC PLANT is to be established at York Haven, Pa., on the Susquehanna River. It is proposed to build a power canal parallel with the river, and using the water to drive 20 water wheels which will be connected to dynamos. It is proposed to transmit the current to neighboring towns for lighting and power purposes. Mr. Harry L. Carter, of Philadelphia, owner of the York Haven Paper Mills, is interested.

THE NEW WATER POWER PLANT at Indian Orchard, Mass., will have three pairs of horizontal turbines of 950 HP. On the second floor will be three electric generators of 450 HP., with a capacity of 15,000 incandescent lights of 16 c. p., and seven generators with a capacity of 840 arc lamps. The current will also be used for driving a 400-HP. motor for commercial arc lighting. It is intended to use the current for lighting the city and the mills, and for driving mill machinery.

LAND BELOW HIGH WATER MARK, on the New York water front, can not be held as private property, according to a late decision of the Appellate Division of the Supreme Court, in the case of Henry W. Sage vs. the City of New York. Mr. Sage owned land on the East River water front, between 94th and 95th Sts., and he enjoined the city from filling in there and claimed title to the bulkhead line. The majority of the court held that the property right to land between high and low water mark is invested in the city by the Dongan charter of 1686, affirmed by the charter of 1777 and reaffirmed by all subsequent charters to 1894. These charters were based on grants made by James II. and George II., through Governor Nicholls and others, and these grants expressly state that waterways up to high water mark shall not be at any time private property. The minority of the court held that in some private grants water fronts were included, and that in this case the evidence was not sufficient to show that they were not to be included. As fifty other cases depend upon this one, the Sage case will probably be carried to the Court of Appeals.

THE WATER CONSUMPTION OF PARIS, says the "Revue d'Hygiene et de Police Sanitaire," touched its maximum on July 9, last, with 633,200 cu. m., or 167,290,440 U. S. gallons per day. Of this volume 64,042,080 gallons were derived from springs, or "eaux de sources;" 62,826,760 gallons were taken from the Seine; 39,101,600 gallons came from the Ourcq and 1,321,000 gallons came from the artesian wells or from Arcueil. Between July 5 and 11 the aggregate consumption was about 62.4 gallons per day per inhabitant; of which only 26 gallons, however, was from the springs, or sources of purer water. While the Parisian authorities note this consumption as abnormal and due to a season of unusual heat, the figures given prove either that the supply of potable water is a limited one, or that there is unusual care in its distribution. Considering the very liberal public use of water in fountains, etc., in that city, the aggregate daily consumption per head of population is very small compared with the lavish use, or waste, of water in American cities. And in the latter cities the best water is used for all purposes, instead of there being several distinct supplies of varying quality to draw upon, as in Paris.

THE GREAT YERKES TELESCOPE, which is to be erected at Lake Geneva, Wis., for the University of Chicago, is nearly completed and the observatory building will be ready for dedication and occupancy on Dec 15. The 40-in. lens for the telescope, which Alvan Clark, of Cambridgeport, Mass., has been grinding for the last year and a half is ready for shipment. This lens is the largest in the world, the next largest being the 36-in. lens in the Lick telescope in California.

BOOK REVIEWS.

POCKET COMPANION, Containing Useful Information Appertaining to the Use of Steel, as Manufactured by the Carnegie Steel Co., Limited, Pittsburg, Pa. For Engineers, Architects and Builders. Edited by F. H. Kindl, C. E., 1896. Morocco flap; 4¼ × 6½ ins.; pp. 284; $2.

A feature of the present edition of this well-known pocket-book is the conformation of shapes, weights and tables of various sections, as well as specifications, to the new standards adopted by the Steel Manufacturers' Association. It also contains additional data on steel construction.

THEATRE FIRES AND PANICS:—Their Causes and Prevention. By William Paul Gerhard, C. E., Consulting Engineer for Sanitary Work. New York: John Wiley & Sons. 12mo.; 175 pp.; $1.50.

This is not a general treatise upon theatre planning and construction, but a statistical study of theatre fires and panics, their causes and frequency, and a series of hints upon the methods of preventing the same, as deduced from the experience of recent years. The prevention of fire and panics is only accomplished by proper location, planning and construction, backed by efficient management and constant inspection. The author briefly outlines these essential elements of safety. Fireproof curtains, stage ventilators, the arrangement of aisles and chairs, fireproof treatment of stage scenery, and safe heating and lighting, are all discussed along with fire-service, life-saving appliances, fire alarms and general questions of management. The work closes with a long list of books, pamphlets, reports, etc., bearing upon theatre construction and theatres generally.

INDUSTRIAL ORGANIC CHEMISTRY: A Hand-Book Adapted for the Use of Manufacturers, Chemists, and All Interested in the Utilization of Organic Materials in the Industrial Arts.—By Samuel P. Sadtler, Ph. D., F. C. S., Professor of Chemistry in the Philadelphia College of Pharmacy and in the Franklin Institute of the State of Pennsylvania; author of a "Hand-Book of

Chemical Experimentation;" etc., etc. Second Revised and Enlarged Edition. Philadelphia: J. B. Lippincott Co. 8vo.; pp. 537; 127 figures; diagrams and tables. Cloth, $5.00; half leather, $5.50.

The range of subjects covered by this volume is amazing. The general plan followed has been (1) to present for the several industries an enumeration and description of the raw materials concerned; (2) the process of manufacture is described; (3) the products are set forth; (4) analytical tests and methods are presented; (5) the bibliography and statistics of each industry, or the most important ones, are given. Owing to the scope of the work the treatment of each subject is generally brief.

The main divisions of the subjects taken up are oils, fats, resins, sugar, starch, fermentation processes, industries based on animal and vegetable fibers and animal tissues, dyeing and coloring.

The first edition of the work was published in 1891. In this edition the body of the text has not been altered further than to make corrections, but some new sections have been added, and the bibliography and statistics have been brought down to 1895. The volume seems to be a most excellent one for ready reference where only the salient features of a process are described. If one does not find here all that is desired the bibliography will direct him to more extended sources of information.

BUILDING CONSTRUCTION AND SUPERINTENDENCE.—By F. E. Kidder, C. E., Ph. D., Architect, Author of "The Architects' and Builders' Pocket Book." Part I.—Masons' Work. New York: William T. Comstock. 8vo.; cloth; pp. 409; 250 illustrations. $4.

This author has long been well and favorably known among architects, and also to a considerable extent among engineers, through his "Architects' Pocket Book." The present volume bids fair to be a very useful book for all who have to do with the construction of buildings. It is written in the light of the most recent practice and seems to cover the subject admirably. It is essentially a practical book, but is founded on good engineering, architectural and business principles.

The first two chapters discuss, respectively, foundations on firm and compressible soils. Next comes a chapter on masonry footings and foundation walls, shoring and underpinning, followed by chapters on limes, cements and mortars, building stones, cut stonework, brick work, and architectural terra cotta. Fireproofing is given some 40 pages, in which the subject seems to be well treated, including a description of some of the best systems of construction now in use. As closely allied to the main subject, a chapter is devoted to iron and steel supports for mason work and skeleton construction. Lathing and plastering and concrete foundations, followed by a chapter on specifications, close the body of the book. Seven brief appendices give some useful tables relating to the strength and other physical characteristics of building materials and a list of building stones.

Aside from the fact that some of the illustrations were made from very poorly drawn originals, and therefore are blurred and dirty, the make-up of the book is very good.

BLOCK AND INTERLOCKING SIGNALS.—By W. H. Elliott, Signal Engineer, Chicago, Milwaukee & St. Paul R. R. "Locomotive Engineering." New York: 1896. Flexible leather; 6 × 9 ins.; pp. 277; illustrated; $3.

Books on railway signaling are so few and, for the most part, so antiquated, that this volume is especially welcome to those who desire a convenient and up-to-date work on a subject which is demanding more and more attention from railway engineers. In the past signal engineering has been almost wholly monopolized in this country by the various railway signal manufacturers, comparatively few engineers outside of these companies having devoted especial attention to it. The reason for this has been doubtless the small use of interlocking and block signals by American railways as a whole, but this condition of things is changing. The railways are rapidly coming to a realization of the advantages of thoroughly signaling their lines, and are demanding the services of men competent to superintend the installation, operation and maintenance of these signals. This makes the field for a good treatise on railway signaling practice a promising one, and the author of this book has shown a timely judgment in presenting his work.

The book before us has its limitations. It aims more toward a popular and general exposition of the subject than toward an exhaustive and technical treatment. As published in "Locomotive Engineering," a paper devoted especially to the interests of the motive power departments of railways, the original articles were admirable for the class of men they were intended to reach. It cannot be said, however, that they serve so well the purpose of the mechanical and civil engineers who desire a technical, scientific presentation of signaling problems and their solution. The book gives these engineers more information than can be had in any other one place, but not as much and not in as technical a form as they would like to have such information given, in view of the great lack of good literature upon railway signaling. These remarks are not presented as a criticism upon the matter given in the volume before us, since this matter is admittedly intended for a certain class of men only, but they are necessary to give a clear idea of the book's limitations.

To give an idea of the contents of the volume in more detail it may be stated that the first nine chapters treat of block signaling, and in them the different manual, automatic and staff systems are explained, with considerable information in relation to maintenance. In Chapter VIII. the costs of operating the simple and controlled manual systems are compared with each other and with those of operating the various automatic systems. The remainder of the book describes the operation and construction of interlocking signals, with special chapters on switch signals and on agreements, contract specifications, installation and repairs. With some of the author's opinions and examples of practice there will be dispute. We note especially the diagram of interlocking signals for a junction of a single with a double track railway given on page 166, which can hardly be recommended as representing the best practice.

In typography and make up the book is generally excellent. The type is good and the illustrations are fairly engraved and printed. The faults are the numbering of cuts by chapters and often an omission of explanatory titles. The book has no index and an inadequate table of contents to supply in part the deficiency. On the whole, however, signal engineers will find the volume an interesting and valuable description of railway signaling practice in this country at the present time.

A MANUAL OF BRIDGE DRAFTING.—By Chas. H. Wright, M. Am. Soc. C. E., Chief of Drafting Department, Edge Moor Bridge Works, and Chas. B. Wing, Professor of Bridge Engineering, Leland Stanford Junior University. University Press, Stanford University, California, 1896. 4to.; 9½ × 12 ins.; flexible canvas; pp. 214; illustrated; $4.

Bridge literature has reached such an unprecedented volume within the last few years that one turns with considerable curiosity to each addition to ascertain what new features or original method of treatment the book presents as an argument for its claim upon the attention of bridge engineers. It is gratifying in the present case, therefore, to find that an attempt has been made to cultivate quite a new field. Each year our technical schools are graduating an increasing number of men who intend to make a specialty of bridge engineering, and usually the first practical work of these men is drafting in the office of some bridge engineer or bridge shop. Fresh from the schoolrooms, these students strike the unfamiliar field of practical exigencies; individual methods of carrying on work peculiar to location, machinery and prevailing requirements of patrons; shop and drafting room precedents and rules; manufacturers' standards; consideration of erection facilities, etc. It is to connect more closely the work of the student and that of the practical bridge draftsman that this book has been written. One of its authors is a practical bridge draftsman; the other is a teacher of bridge designing to college students.

The contents of the volume before us are perhaps best given by repeating the chapter headings under which the matter is presented. These are: (1) Details of Plate Girders, Lattice Girders, Trestle Bents, Floor Beams and Track Stringers; (2) Details of Pin Connected Spans; (3) Details of Pin-Connected Spans, Continued; Tables of Useful Information, etc.; (4) Bridge Drafting; (5) Shop Work and Inspection; (6) Bridge Erection. Each chapter contains drawings of details illustrating and supplementing the text and a variety of standard tables and diagrams for facilitating calculations. These tables and diagrams have the value of being those actually used by a large and well-known bridge company, and besides their practical working value are useful as indicating the manner and methods of using time-saving devices by practical bridge builders. In the chapter on Bridge Drafting is given the organization of a bridge drafting department, and instructions for arranging, lettering and recording drawings, forms for shipping bills, etc. A portion of this chapter and of that on Bridge Erection was published in Engineering News of Feb. 7 and April 25, 1895.

In the particular field it is designed to cover, the book is on the whole a useful one, but it fails in not being uniformly useful in all parts. Some of the tables and diagrams are of universal and lasting usefulness, some are useful only locally, and still others are already antiquated, or will soon become so. The authors, however, partly atone for this last fault by announcing that additions and revisions to these tables will be published from time to time.

In the matter of its make-up the book deserves some criticism, especially in respect to the clumsy and careless lettering of many of the drawings. In this respect, however, the conditions are no worse than those found in most sheets of bridge drawings which come from our bridge manufacturers' drafting rooms, and which are the natural result of hasty production. Despite this, one ought not to find in a manual for the instruction of bridge draftsmen a seeming encouragement of the fault so common and yet so easily corrected as careless lettering. It is not copper plate letters that are wanted, but neat letters, and no such slovenly letters of mongrel style and form should appear as are some of those on the drawings on Plate 28. It is interesting to compare this, to illustrate our point, with the lettering of the cuts on pp. 211 and 213, which are reprinted from Engineering News with the standard lettering used by this Journal.

HIGHER MATHEMATICS.—A Text Book for Classical and Engineering Colleges. Edited by Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and Robert S. Woodward, Professor of Mechanics in Columbia University. New York: John Wiley & Sons; 8vo.; pp. 600; $5.

This book, according to the publishers' announcement, is designed especially for the use of junior and senior classes in colleges and technical schools, but is equally well adapted to the use of advanced students and readers of mathematics generally; containing a concise treatment of subjects not commonly found in text books, but upon which lectures are now given in the best classical and technical institutions. The work is divided into eleven chapters, each by a different author. Each chapter, so far as it goes, is complete in itself, and is intended primarily to give a clear idea of the leading principles of the subjects treated. The headings of the several chapters are as follows

I. "The Solution of Equations," by Prof. Mansfield Merriman. II. "Determinants," by Laenas Gifford Weld, Professor of Mathematics in State University of Iowa. III. "Projective Geometry," by Geo. Bruce Halstead, Professor of Mathematics in University of Texas. IV. "Hyperbolic Functions," by James McMahon, Associate Professor of Mathematics in Cornell University. V. "Harmonic Functions," by William E. Byerly, Professor of Mathematics in Harvard University. VI. "Functions of a Complex Variable," by Thomas S. Fiske, Adjunct Professor of Mathematics in Columbia University. VII. "Differential Equations, by W. Woolsey Johnson, Professor of Mathematics in the U. S. Naval Academy. VIII. "Grassmann's Space Analysis," by Edward W. Hyde, Professor of Mathematics in University of Cincinnati. IX. "Vector Analysis and Quaternions," by Alexander Macfarlane, Lecturer in Electrical Engineering in Lehigh University. X. "Probabilities and Theory of Errors," by Prof. Robert S. Woodward. XI. "History of Modern Mathematics," by David Eugene Smith, Professor of Mathematics in Michigan State Normal School.

The well-known reputation of Professors Merriman and Woodward is a sufficient guarantee of the excellence of this work, and it will, no doubt, prove a valuable addition to the libraries of those whose tastes incline in the direction of higher mathematics, and a useful text book to mathematical students. The progress of mathematical investigation during the present century has been so great that, in the words of the preface, "the mere quantity of information available presents a formidable obstacle to the simultaneous attainment of the breadth and depth of knowledge which characterized the mathematician of a generation ago. * * * Hence the student who seeks to gain a comprehensive view of the mathematics of the present day needs most of all that sort of guidance which fixes his attention on essentials and prevents him from wasting valuable time and energy in the pursuit of non-essentials." Quoting further from the preface:

During the past 20 years a marked change of opinion has occurred as to the aims and methods of mathematical instruction. The old ideas that mathematical studies should be pursued to discipline the mind, and that such studies were ended when an elementary course in the calculus had been covered, have for the most part disappeared. In our best classical and engineering colleges the elementary course in calculus is now given in the sophomore year, while lectures and seminary work in pure mathematics are continued during the junior and senior years.

The change in the college course here referred to gives rise to the question whether it is a beneficial one. If the mathematical course ending in calculus is not given for the purpose of disciplining the mind then its only other reason for existence is that it furnishes a tool which is necessary to the prosecution of the higher courses in mechanics and in engineering theory and practice. The spending of time in an engineering course on higher mathematics, beyond calculus, can only be justified on the ground that a knowledge of these higher branches is a useful tool, enabling the engineer to accomplish something which he could not accomplish without it. It cannot be claimed for it that it is needed as a mental discipline, for if a student in his sophomore year acquires the calculus so well as to be able to use it in problems of applied mechanics and thermodynamics, and during the junior and senior years studies those branches of engineering science and art which require the application of the calculus, together with the most intense concentration of the mind upon the problems at hand, no higher form of mental discipline can be given by quaternions or hyperbolic functions. On the contrary it is well known that too great devotion to mathematical studies tends to narrowness of intellect, and is therefore detrimental to the training of an engineer. The use of the higher mathematics as a tool in engineering problems is exceedingly rare. Probably not one in a hundred engineers in practice can, five years after graduation, work out a problem in calculus without reference to a book, and not one in a thousand probably ever needs hyperbolic functions. Calculus may be necessary for the engineering student both as a mental discipline and as a tool to be used in the study of applied mechanics, but higher mathematics, we think, he can do very well without, unless he intends to devote his life to original research in physics, electrical theory, etc., in which case, of course, it may be of great service.

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